UNIVERSITY OF BRISTOL

THE ANNUAL REPORT

OF THE

Agricultural and Horticultural Research Station

(*THE NATIONAL FRUIT AND CIDER INSTITUTE*)

LONG ASHTON, BRISTOL

1961

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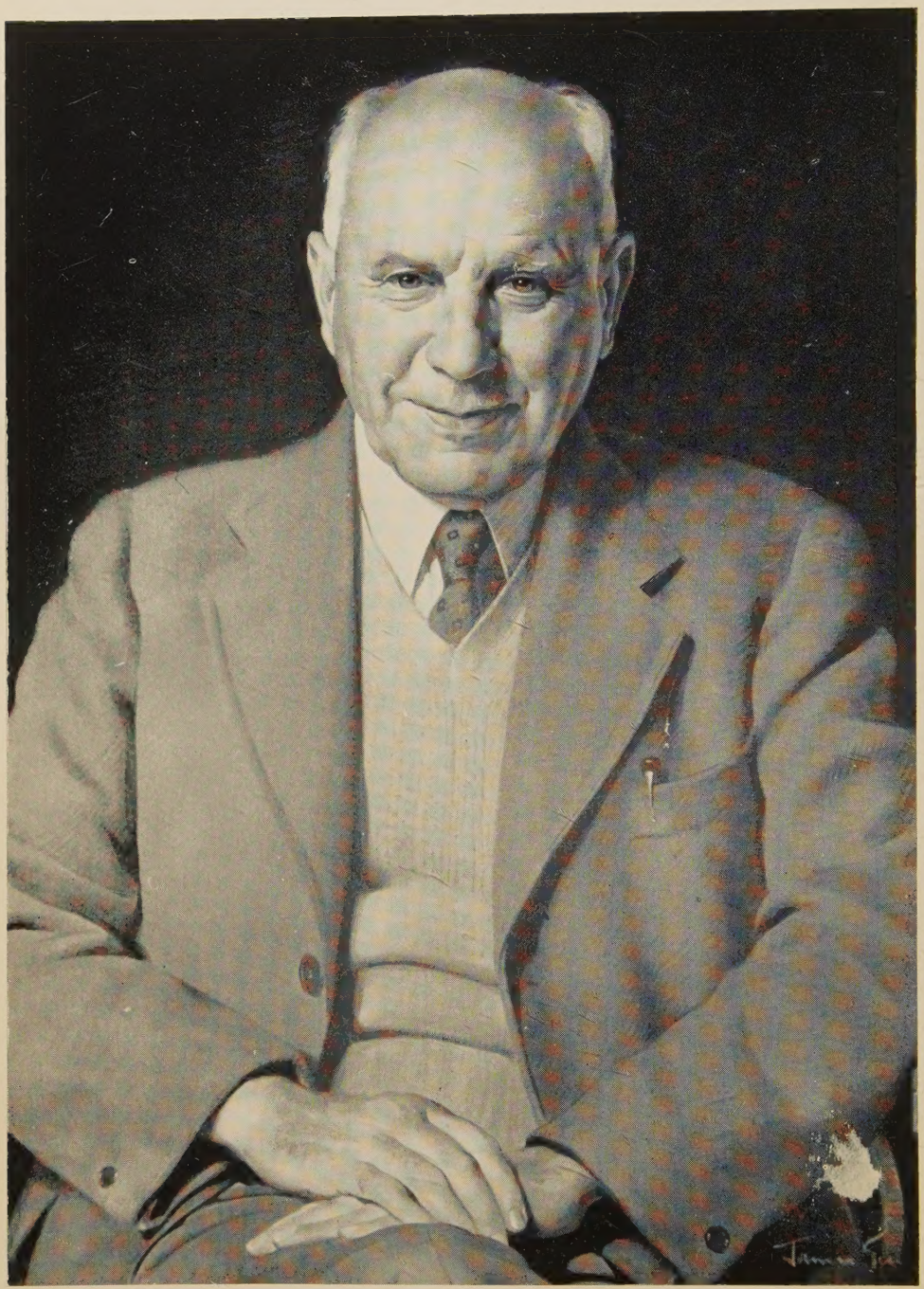

From a portrait by James Gunn, R. A.

PROFESSOR B. T. P. BARKER

In Memoriam.

Professor B. T. P. BARKER, C.B.E.

Within a year of the foundation of the National Fruit and Cider Institute, B. T. P. Barker was appointed as its Director. Almost single-handed he carried the Institute through its first critical years and negotiated its development to a State-aided Research Station : in his 38-year Directorship he took Long Ashton to a place in the first rank of British agricultural research institutes.

He came to Long Ashton in 1904 from Cambridge, where he had been a Scholar of Gonville and Caius College, and a research microbiologist. Building on the foundations laid by Robert Neville Grenville, Barker quickly established effective programmes of research into the chemical and microbiological problems of cider making. He also extended his interests to cider orcharding, and within a very few years he had gained the confidence and goodwill of both farmers and cider-makers.

Other contacts were made with members of the staff of the (then) University College of Bristol. These helped to pave the way to the formal association of the National Fruit and Cider Institute with the University of Bristol in 1912 under a scheme of the Board of Agriculture for the provision of research and technical advice in agriculture and horticulture. By this new arrangement a Department of Agriculture and Horticulture was established in the University, and Barker, as its head, was appointed Professor of Agricultural Biology. At the same time the research programme was extended to include commercial fruit culture, and the Department also became the advisory centre for agriculture and horticulture in the Bristol Province.

During the First World War, Barker was actively engaged in researches on the preservation of fruit by canning and bottling and jam and jelly manufacture, and arising from this the Chipping Campden Research Station was established in 1918 and became associated with the University of Bristol in 1921, with Barker acting as director of the Station, in addition to Long Ashton, from 1921 to 1935.

During Barker's tenure of the Chair of Agricultural Biology, the graduate staff at Long Ashton increased from 4 to 33 ; while the number of graduate advisers rose from 2 to 27. The first block of laboratories was erected at Long Ashton in 1914, with successive extensions in 1927, 1931 and 1932, the whole forming what is now the Barker Laboratory. The Station acreage expanded from 20 to 255, with corresponding increases in glasshouses, orchard buildings and equipment, and in pilot plant for cider and fruit juice investigations.

Although this continuing growth brought heavy administrative burdens, B. r never relinquished his own research activities. He made important contributions to pomology and the study of fungicidal action, but his major work was on cider microbiology and its practical applications, a subject on which he became a world authority. His findings created the basis on which the production of cider and perry has been developed from a minor farm activity to a large-scale industry. After his retirement from the Directorship in 1943, Barker continued to work at Long Ashton for a further seven years as a member of the Cider and Fruit Juices Section ; his publications appeared in the *Annual Report* up to 1951. His unique knowledge of cider led to

numerous calls on his services as a judge in national competitions, such as the Royal, the Bath and West and the Three Counties Agricultural Shows, and at the Brewers' Exhibition.

In the field of general horticulture he was for many years an examiner for the National Diploma in Horticulture of the Royal Horticultural Society, and with Sir Ronald Hatton was joint editor of the *Journal of Pomology and Horticultural Science* from 1924 until 1944. The Royal Horticultural Society recognized his services to horticulture by electing him an Honorary Fellow and by the award of a Veitch Memorial Trust Gold Medal. He was created C.B.E. in 1952.

Barker was a man of great personal charm and had many interests. In his younger days he was a keen player of cricket and hockey and also enjoyed tennis and billiards, while in his later years he was often to be seen enjoying a weekly round of golf on the Long Ashton course. He was an enthusiastic supporter of the University of Cambridge in rowing, cricket and rugby football, and, until prevented by illness in recent years, seldom failed to be present at the annual Oxford and Cambridge contests. He was also a talented pianist and a redoubtable chess player, and for many years he played regularly in county chess tournaments.

In spite of partial disablement in his later years, Barker continued to the end of his life his attendance at the annual Sampling Days and Christmas Lunches at the Research Station. His death on 19th December 1961 at the age of 84 takes from us one of the pioneers of agricultural research in Britain and a memorable personality whose passing will be deeply felt by all his friends and colleagues.

INTRODUCTION.

By H. G. H. KEARNS, Director.

With the name of Professor Wallace perpetuated by the Wallace Laboratory, it seemed appropriate to rename the original Main Laboratory building after Professor Barker; it will therefore be known as the Barker Laboratory. It will continue to house the Director's offices, the Library, the Committee Room, the Scientific Liaison Officer and the laboratories of the Cider and Fruit Juices and the Domestic Food Preservation Sections. It is hoped that a complete overhaul will improve a building valued for its past associations.

Mr. W. Ness, C.B.E., who had administered the finances of the Agricultural Research Council for some years, retired on 31st October, and was succeeded by Dr. W. E. Berry, from 1938 to 1942 Plant Physiologist on the Long Ashton staff and more recently an Assistant Secretary in the Ministry of Aviation. The Research Station is greatly indebted to Mr. Ness for his sympathetic help with financial problems.

Professor T. K. Ewer, who was appointed to the Chair of Animal Husbandry in the University in 1961, has succeeded Professor A. Messervy as a representative of Senate on the Agricultural Committee. The Finance and Business Sub-Committee of the Agricultural Committee in July accepted with much regret the resignation of Major W. F. Q. Shuldham whose many years of service on this Sub-Committee have been greatly appreciated. He will continue as a member of the Agricultural Committee. Mr. C. E. Hudson, C.B.E., V.M.H., Senior Advisory Officer (Horticulture) of the Ministry of Agriculture, Fisheries and Food since 1948, retired on 17th November, and was succeeded by Mr. P. H. Brown, formerly Director of Efford Experimental Horticulture Station. Mr. Hudson has been a valuable friend to the Station as a member of the Agricultural Committee and the Finance and Business Sub-Committee for many years, and we are very glad that he is able to continue as a co-opted member of this Committee.

Major H. W. W. Hoskyns has been re-appointed, and Professor E. W. Yemm and Captain A. F. Q. Shuldham have succeeded Professor Wallace and Mr. Francis Smith as representatives of the Ministry of Agriculture, Fisheries and Food, on the Governing Body of the National Fruit and Cider Institute for three years to 1964.

Mr. Colin D. Ross, O.B.E., Regional Director of the South West Region of the N.A.A.S., retired on 9th March and was succeeded on 1st May by Mr. E. Llewelyn Harry, C.B.E., previously Regional Controller of the East Midland Region.

Among the many links with other organizations during the year, co-operation with the N.A.A.S. must first be mentioned. The Annual Refresher Course on 11th and 12th July was attended by 41 N.A.A.S. and 10 L.E.A. Horticultural Officers. Dr. Bould, Dr. Smith, Dr. Corke and Mr. Hobbis formed a panel of speakers at a meeting for growers arranged by the N.A.A.S. at Knightwick, Worcestershire, on 4th December, to discuss factors influencing the yield of black currants. Dr. Luckwill has been appointed to represent Long Ashton on

the Ministry of Agriculture committee newly formed to review research on herbicides and make recommendations for use by N.A.A.S. officers.

At the request of the Colonial Office, Professor Kearns visited Kenya, Zanzibar, Tanganyika and Uganda between 29th January and 9th March, to review and give advice on spraying methods for pest and disease control on a variety of crops, including coffee, cotton and limes. At the invitation of the Government of the Sudan he also visited the Sudan Gezira to advise on the spraying of cotton in an area of some half-a-million acres of irrigated land between the Blue and White Niles. He paid a second visit to the Sudan between 7th and 23rd October to survey the spraying in progress and to devise new equipment.

A new Government Department of Technical Co-operation was set up during the year to deal with technical aid to overseas territories, taking over the work formerly carried out by the Foreign Office, the Commonwealth Relations Office and the Colonial Office. Professor Kearns has accepted an invitation from this Department to serve on their Consultative Panel for Agriculture for an initial period of three years. He will continue to serve on the Scientific Advisory Committee of the Agricultural Chemicals Approval Scheme and the A.R.C. Technical Committee on Spray Drift, of both of which he is Chairman, the Royal Horticultural Society's Fruit Group Committee, the Bath & West Society's Experiments and Education Committee, the National Fruit Trials (Brogdale) Advisory Committee and the Luddington Experimental Horticulture Station Advisory Committee. He also served during the year on the Local Executive Committee of the Bath & West Society, which organized the Annual Bath & West Show, held from 31st May to 3rd June in the grounds of Ashton Court, Bristol. Mr. Marsh deputized for him on the Showyard Sub-Committee.

Dr. Martin has accepted an invitation from the Agricultural Research Council to serve on the Research Committee on Toxic Chemicals set up under the chairmanship of Professor A. C. Frazer. Dr. Pollard has continued to serve on the Horticultural Marketing Council and to assist the Council with the preparation of opalescent apple juice and blends for consumer tests and for sampling by the Council's Fruit Processing Committee.

Among assistance given by members of staff to other organizations must be mentioned Mr. Clarke's services to the Pig Industry Development Authority and to Bristol Siddeley Engines Ltd., for whom he has completed the work referred to last year. Dr. Carr is representing the Society of General Microbiology on the Executive Committee of the Second Symposium on Fermentation to be held in London in 1964. Dr. Nicholas gave eight lectures on " Electron transport systems " to the honours students in Biological Chemistry at Bristol University between February and March. Mr. Marsh and Dr. Martin were sectional chairmen at the British Insecticide and Fungicide Conference, held at Brighton from 6th to 9th November and sponsored by the Association of British Manufacturers of Agricultural Chemicals.

The Station has co-operated with the University Radioactive Protection Officer, Mr. H. F. Freundlich, and the Radioactive Protection Committee set up by the University, in arrangements for the protection of staff exposed to radioactive material, and Dr. Thomas has been appointed the Departmental Radioactive Protection Officer for Long Ashton.

A meeting of representatives of the cider industry and growers was held at the Station on 25th July to consider methods of mechanically harvesting fruit.

Preliminary experiments were carried out by the Cider and Fruit Juices Section on the use of the Morris Hedgehog harvester. An informal meeting of the Field Officers of Messrs. Beechams Foods Ltd. and members of the Long Ashton staff was held at Long Ashton on 26th September, to discuss problems of black currants.

A meeting arranged by the Anti-Locust Research Centre, London, was held at Long Ashton on 15th September, when the detection and measurement of spray residues were discussed informally by members of the Centre staff, the Colonial Pesticides Research Committee, the Tropical Pesticides Research Unit, the National Vegetable Research Station, the National Institute of Agricultural Engineering and Long Ashton staff.

A visit from members of the staff of East Malling was arranged from 25th to 27th April, when a group of seven members of the Entomology Section and two from the Plant Protection Chemistry Section visited Long Ashton. It is hoped to arrange a return visit of the Long Ashton Plant Pathology Section to East Malling next year. Professor Kearns and Dr. Luckwill attended a meeting at East Malling Research Station on 23rd June to discuss virus problems in top fruit.

At the request of the Director of the Royal Botanic Gardens, Kew, Professor Kearns, Dr. Morgan and Mr. Russell designed, for installation by the Ministry of Works, automatic watering equipment which will provide a fine spray over the whole Palm House at timed intervals.

The Station is greatly indebted to Messrs. Boots Pure Drug Company Ltd. for an increased grant, under a seven-year covenant, permitting two further two-year scholarships and one one-year scholarship of £500 per annum to be awarded. Our thanks are also due to the staff of the Medical Research Council Radiotherapeutics Unit at Hammersmith Hospital for their generous co-operation with Dr. Nicholas in experiments involving the use of radio-active nitrogen.

We have been glad to welcome the High Commissioner for New Zealand, the Hon. T. L. Macdonald, and Mrs. Macdonald, who visited us on the invitation of the Vice-Chancellor on 24th July ; Professor E. N. Mishoustin of the Academy of Sciences, U.S.S.R., a Corresponding Member of the Royal Society, through whom his visit on 6th February was arranged ; three Russian horticulturalists, Mr. S. N. Pronine, Mr. S. N. Stephanov and Mr. D. D. Kovalenko, who were studying mechanization in horticulture and market gardening and methods of propagating apples ; and a party of Agricultural Economists from Newton Abbot, who on 11th July included Long Ashton in their farewell tour of Bristol University on their transfer to the University of Exeter. We were pleased to be able to offer our Refectory and the services of the Refectory staff for the Annual Dinner and Dance of the Royal Institute of Chemistry, Bristol and District Section, on 24th November, when Sir William and Lady Slater and Professor and Mrs. Kearns were the guests of honour.

The series of Staff Lectures arranged for the Winter 1961/62 included one by Mr. R. D. Reid of the Scottish Horticultural Research Institute, Auchincruive, on strawberry breeding. This was given on 8th December and was much appreciated not only by Station staff but by Members of the National Fruit and Cider Institute who were invited to attend.

Staff.

Resignations :

We were sorry to lose by resignation two members of the Entomology Section staff during the year. Mr. T. E. Cobbald left on 30th June to undertake farming on his own account, after holding a post under a Colonial Development and Welfare Scheme since 1st August 1955. He had undertaken investigations on mist-blower sprayers and designed several experimental machines.

Dr. C. G. L. Furmidge resigned from 30th September in order to take up a post with Shell Research Ltd., Woodstock Agricultural Research Centre, Sittingbourne, Kent. Dr. Furmidge was appointed Physical Chemist in the Entomology Section from 1st September 1954, and made some valuable contributions to our knowledge of the surface active materials used in sprays.

Mr. George Kitchingham, who had served the Station for 33 years, retired on 15th February after a period of ill-health, but we are glad that he is able to remain in his cottage nearby and to visit the Station frequently now that his health has improved again.

Appointments :

With the appointment of Mr. P. F. Rushby as Senior Photographer, as from 11th September, the Station has for the first time a member of staff employed fulltime on photography. We are indebted to those who have in the past included photography among their other duties—Mr. George Jones, Mr. Mapother and Miss Tapscott. With the improved studio and darkroom facilities in the Wallace Laboratory, it will now be possible for Mr. Mapother, who continues to supervise the photographic service, and Mr. Rushby to offer more assistance to staff. Mr. Rushby comes to us after eight years' service as photographer with the Bristol Aeroplane Company and the Westland Helicopter Division, Weston-super-Mare.

For other resignations and appointments see *List of Staff*—1961, pp. 4-7.

Visits Abroad :

As reported earlier, Professor Kearns visited East Africa and the Sudan from 29th January to 9th March, and the Sudan again from 7th to 23rd October.

Mr. Hobbis and Dr. Luckwill visited Italy from 20th to 29th July to study apple and pear growing in the Adige valley and in the Po valley near Ferrara. Copies of their report on the visit were circulated to N.F.C.I. Members, the Agricultural Committee, the National Association of Cider Makers, the N.F.U., the A.R.C. and East Malling Research Station. Their report was received with considerable interest by fruit growers in this country.

Dr. Pollard attended the International Fruit Juice Union Scientific Commission Meeting, Wageningen, Holland, from 19th to 21st April. He also visited Spain for ten days in August at the invitation of Messrs. John Harvey and Sons, to obtain information on the blending of apple juices with unfermented grape juice.

At the invitation of Messrs. Beechams Foods Ltd., Dr. Smith visited Poland from 1st to 14th May in company with Mr. Deakin of Beechams, to carry out a survey of black currant growing in that country.

Dr. Martin attended the 18th International Congress of Pure and Applied Chemistry in Montreal from 6th to 12th August. He left the U.K. for Canada on

24th July and visited various research establishments in Canada and the U.S.A. engaged on the analysis of spray materials ; he presented a paper on the translocation of mercury in plants and was chairman of one of the half-day sessions of the Symposium on the Analysis, Degeneration and Metabolism of Pesticides Residues.

Dr. Nicholas was granted leave of absence for six months to accept an invitation from the University of Wisconsin, U.S.A., to be Visiting Professor in their Department of Biochemistry, as from 1st October.

Degrees, Honours, etc. :

The award of the M.B.E. to our Secretary, Mr. A. L. Leggett, in the Birthday Honours List in June, has given great pleasure to his many friends among Members of the Institute and Station staff.

Mr. E. G. Bradfield, Experimental Officer, Nutrition of Fruit Plants Section, was awarded the degree of M.Sc.(Bristol) in July for a thesis entitled " A study of some factors which affect the Titan Yellow reaction in the determination of magnesium in plant material ".

Mr. D. P. Hucklesby, Experimental Officer, Plant Physiology Section, was awarded the degree of M.Sc. (London) in December for a thesis entitled " A histological study of Whiptail in cauliflower plants ".

Miss Gillian North-Smith (now Mrs. Faulkner), Assistant Experimental Officer, Pomology Section, was elected to full membership of the Institute of Biology on 28th April for her dissertation on " The systematics of perry pears ".

Miss J. M. Bradford, Assistant Experimental Officer, Plant Biochemistry Section, was awarded the Fruiterers' Company Prize for 1961 in view of her excellent performance in the College of Technology classes during the year.

Mr. F. W. Hynam, Plantations, gained second prize in the Mendip Ploughing Match in the 3-furrow, open class.

Buildings and Land.

With the transfer of staff to the Wallace Laboratory it will now be possible to give a long-needed overhaul to the Barker Laboratory. A capital grant has been made towards the alterations, including complete reflooring of the building, and the provision of new equipment. The work will commence in 1962 and is unlikely to be completed until the end of 1963.

The Biology Annexe, built in 1953 as a store for the Biology Building, has been in continual use as temporary laboratories and offices pending completion of the new buildings. Now it is vacated it will provide much needed additional space for the biologists.

In addition to the overhaul of the Barker Laboratory, there is an urgent need to reconstruct the milling shed of the Cider and Fruit Juices Section, and also to provide a new exit on to the roadway from the Research Station. The milling shed, built in 1927 and of approximately 5,000 sq. ft. floor area, consists of a steel framework clad with galvanized walls and roof. Milling and pressing of large quantities of cider fruit is no longer necessary, and the shed now houses valuable pilot plant for small-scale investigations. The galvanized structure is ill-adapted for this type of investigation, and it is proposed to modify the building over a period of four years to suit its new use. The galvanized walls will be replaced with brickwork and the roof with corrugated asbestos and roof

lights. The inside of the building will be divided into heated and insulated compartments so that the equipment can be protected from frost.

The principal exit from the Research Station is most dangerous, as it leads directly on to the main Bristol/Weston-super-Mare road. It is proposed to close it and to construct a new entrance on the west boundary of the property adjoining a little-used lane. This will involve the removal of two small greenhouses and shedding, and the construction of a new cement roadway : it is hoped that the work will be completed in 1963.

The scheme commenced in 1959 for the construction of eight concrete plunge beds, each 100×4 ft, with pathways and automatic watering, adjacent to the Greenhouse Laboratories, has been completed.

New woodworking machines have been installed in the estate workshops.

The occupation of the Wallace Laboratory called heavily on the services of the workshops during the year. The surrounds of the Laboratory were tidied up, levelled and sown to grass, and kerbing of service roads constructed. Half of a cottage previously occupied by some of the office staff was reconverted to domestic quarters.

Open Days.

Cider Sampling Day was held on Thursday, 4th May. For the first time since its institution, the morning tasting session did not take place in the Cider Milling Shed, but was held in the more comfortable surroundings of the Refectory. The samples tasted included perries from old orchards and from the new bush plot at the Station, and a range of perries from dessert pear varieties. The single-variety ciders shown included some from fruit showing the condition " Water-core ". A series of blended ciders from the different cider areas aroused interest and comment. The occasion was attended by over 120 guests, and was followed by lunch in the Cider House and tours of exhibits there and in the plantations in the afternoon.

In view of the Opening Ceremony of the Wallace Laboratory on 6th July, the Annual Field Day for Members and the Annual General Meetings of the Members and the Governors of the National Fruit and Cider Institute were held on Thursday, 7th September, instead of in July as is customary. Demonstrations included the establishment of young apple trees in sward, the control of Big Bud Mite of black currants, the development of opalescent apple juice, the production of virus-free clones of apples and the suppression of grass around orchard trees. Guests were given lunch in the Refectory, and the business meetings of the Institute followed in the afternoon.

Organized Parties, 1961.

Barton Hill Settlement.
Bath College of Domestic Science.
Bristol Civil Defence Corps.
Bristol Civil Defence Corps, Welfare Section.
Bristol University Agricultural Economists.
Bristol University Botanical Society.
Bristol University Employees' Association.
Bristol University Microbiology Students.
Bristol Young Farmers' Club.
British Oil and Cake Mills Horticultural Society.
Clifton College Science Students.
Clifton High School for Girls : Science Sixth.
College of St. Matthias, Fishponds, Bristol.

Domestic Food Preservation Courses : Deep Freezing : Fruit and Vegetables (2).
Downend County Secondary School.
Dublin University College, Botany Students.
Filton and Patchway Camera Club.
Frenchay and Hambrook Horticultural Society.
Gloucestershire Fruit Growers.
Institution of Electrical Engineers : W. Centre Supply Group.
King Edward VI High School for Girls, Birmingham.
Kingswood School, Bath : Biology Students.
Lackham School of Agriculture.
Ledbury Young Farmers' Club.
Long Ashton Horticultural Society.
Loyal Order of Moose : Vocational Guidance Course.
Lye and Wollescote Allotments and Gardens Association.
N.A.A.S. and L.E.A. Horticultural Officers.
Newton Park Training College, Bath.
Reading University Horticulture Students.
St. Agnes Youth Fellowship.
St. Mary's College, Cheltenham.
St. Mary Redcliffe Youth Club.
Somerset Farm Institute Horticulture Students.
South Gloucestershire Science Teachers' Association.
Waterperry Horticultural School.
Westbury-on-Trym Townswomen's Guild.
Weston-super-Mare Grammar School for Girls.
Wiltshire Rural Studies Association.
Wiltshire Science and Rural Science Teachers.
Worcestershire Farmers' Union : Pershore and Upton-on-Severn Branches.

Visitors from Overseas, 1961.

Argentina : Mr. R. F. Worlock, San Rafael, Mendoza.

Australia : Miss Joan Bain, C.S.I.R.O., Sydney.
Dr. N. J. Barrow, C.S.I.R.O., Armidale.
Mr. P. Baxter, Melbourne.
Dr. S. M. Bromfield, C.S.I.R.O., Canberra.
Mr. C. E. Cole, Melbourne.
Dr. B. D. Cuming, Melbourne.
Mr. R. S. Horne, Melbourne.
Mr. W. J. Johnston, Hastings, Victoria.
Dr. T. L. Lewis, C.S.I.R.O., Hobart, Tasmania.
Dr. K. C. Marshall, C.S.I.R.O.
Mr. K. B. Maynard, Melbourne.
Mr. and Mrs. T. C. Miller, Adelaide.
Mr. E. R. Peacock, Brisbane.
Mr. F. W. Renouf, Tyabb, Victoria.
Dr. and Mrs. P. J. Skerman, University of Queensland.

Belgium : Dr. A. Soenen, Gorsem, St. Troud.

British Guiana : Miss D. L. Hamilton, Georgetown.

Canada : Dr. C. E. Colquhoun, London, Ontario.
Dr. and Mrs. J. L. Dionne, Lennoxville, Quebec.
Dr. R. H. Fisher, Ontario.
Dr. F. B. Johnston, Ottawa.
Dr. R. A. Ludwig, Plant Research Institute, Ottawa.
Dr. B. C. Matthews, Guelph.
Dr. C. D. Nelson, Queen's University, Kingston, Ontario.
Dr. W. E. Sackston, Macdonald College, Quebec.
Mr. John Smith, Kelowna, British Columbia.
Dr. L. P. S. Spangelo, Ottawa.
Dr. E. Y. Spencer, London, Ontario.
Mr. Charles H. Wake, Ottawa.
Dr. M. F. Welsh, Summerland, B.C.
Dr. D. J. Wort, University of British Columbia.

Ceylon : Dr. and Mrs. E. D. C. Baptiste, Rubber Research Institute.
Mr. J. E. Cranham, Tea Research Institute.

Czechoslovakia : Mr. L. Chvojka, Prague.

Denmark :	Dr. H. Andersen, Copenhagen.
	Mr. J. J. Jorgensen, Odense.
	Mr. F. Larsen, Copenhagen.
Eire :	Mr. A. M. McGuire, Dublin.
Finland :	Miss E. Laakkonen, Lansi-Sakyla.
France :	Dr. F. Dennis, Gif-sur-Yvette.
	Professor J. P. Nitsch, Gif-sur-Yvette.
	M. J. E. Prevost, Shell Chemicals, Paris.
Germany :	Miss Charlotte Buchholz, Institute for Plant Nutrition, Berlin-Dahlem.
	Mr. G. Leybold, Lauffin.
	Dr. F. Radler, Pfalz.
	Mr. G. Thiessen, Hanover.
	Dr. W. Zehler, Potash Ltd., Hanover.
Holland :	Mr. J. C. Bensink, Daventer.
India :	Dr. T. K. Bose, Calcutta.
	Mr. R. D. B. Hughes, Manjolai, South India.
	Dr. T. N. D. Pillay, Hyderabad.
	Mr. R. Radcliffe, Hassar District, South India.
	Mr. S. Rao, Nagpur, Mahatashtra.
	Professor P. K. Sen, Calcutta University.
	Dr. K. S. Thind, Panjab University.
Israel :	Dr. S. H. Levinson, Hebrew University, Rehovot.
	Mr. Z. Mitchnick, Rehovot.
Italy :	Dr. Vittorio Marzi, University of Bari.
Jamaica :	Mr. A. V. Allen, Christiana.
	Mrs. D. E. Boland, Banana Board, Kingston.
	Dr. D. S. Meredith, Banana Board, Kingston.
	Mr. and Mrs. Michael Shaw, Sugar Research Department.
Japan :	Dr. and Mrs. Y. Yamada, Kyushu.
Kenya :	Dr. E. D. Bumpus, Kitale.
	Mr. G. D. Glynne Jones, Pyrethrum Board, Nakuru.
	Mr. N. H. Hardy, Pyrethrum Board, Nakuru.
	Mr. and Mrs. T. H. Jackson, Ministry of Agriculture.
	Mrs. E. Mwendar, Lower Kabete.
	Dr. E. W. Russell, E.A.F.F.R.O., Kikuyu.
Malaya :	Mr. C. W. Brookson, Rubber Research Institute.
	Dr. B. R. Buttery, Rubber Research Institute.
	Mr. L. H. Ho, Kuala Lumpur.
	Mr. E. K. Ng, Rubber Research Institute.
	Mr. T. K. Teoh, Kuala Lumpur.
New Zealand :	Dr. R. L. Bieleski, D.S.I.R.
	Mr. J. Bruce Brown, Wellington.
	Mr. F. Hurst, Dominion Laboratory, Wellington.
	The Hon. T. L. and Mrs. Macdonald, Wellington.
	Miss M. H. Sowerby, Dunedin.
Nigeria :	Mr. D. A. Guymer, Samaru.
	Mr. P. Mulholland, Jos.
	Mr. T. E. Ryall, Kaduna.
	Dr. K. W. Smilde, W.A.I.F.O.R., Benin City.
North Borneo :	Mr. G. R. Conway, Jesselton.
	Mr. J. W. Gillespie, Tawau.
	Mr. T. J. Quinlivan, Tawau.
	Mr. T. H. Williams, Tawau.
Norway :	Mr. E. Kvaale, Hermanswerk.
Pakistan :	Mr. M. A. Qadeer, Ichhra, Lahore.
Philippines :	Mr. V. G. Cedillo, Manila.
Poland :	Dr. A. Rejman, Warsaw.
Rhodesia :	Mr. H. P. Nursten, Lusaka, Northern Rhodesia.
South Africa :	Mr. J. I. B. Cuthbert, Pietermaritzburg.
	Mr.. J. F. du T. Hugo, Stellenbosch.
	Mr. J. M. Kotze, Johannesburg.
	Mr. M. S. le Roux, Stellenbosch.
	Mr. M. E. Sumner, University of Natal.
	Dr. F. C. J. Zeijlemaker, Pietermaritzburg.
Sudan :	Mr. Salim Amir, Gezira.
	Dr. D. P. Drover, University of Khartoum.

Sweden :	Mr. E. Jakobsson, Göteburg.
	Mr. E. Karlsson, Anrika.
	Mr. K. Lindholm, Stockholm.
	Dr. C. Lindquist, Boräs.
	Mr. H. C. Madsun, Klippan.
	Mr. S. Nyberg, Vännäs.
	Mr. B. Ogren, Fagersta.
	Miss K. Olsson, Solna.
Tanganyika :	Mr. D. A. Burdekin, Lyamungu.
	Mr. L. M. Fernie, Lyamungu.
	Mr. C. W. Lee, Arusha.
	Mr. P. O. Park, Arusha.
	Mr. R. G. Tapley, Lyamungu.
Uganda :	Mr. D. J. Butt, Kampala.
U.S.A. :	Professor J. Carew, East Lansing, Michigan.
	Dr. D. M. Coulson, Palo Alto, California.
	Mr. E. Gould, Kearneysville, West Virginia.
	Dr. A. Marcus, Beltsville.
	Dr. I. J. McIlrath, University of Chicago.
	Mr. and Mrs. J. C. Snyder, Pullman, Washington.
U.S.S.R. :	Professor E. N. Mishoustin, Academy of Sciences, Moscow.
	Mr. D. D. Kovalenko, Agricultural Machinery Co-operative, Moscow.
	Mr. S. N. Pronine, Ministry of State Farms, Moscow.
	Mr. S. N. Stephanov, Horticultural Research Institute, Moscow.
	Mrs. I. A. Yakoushkina, Ministry of Agriculture, Moscow.
Yugoslavia :	Mr. M. Dzamic, Belgrade.
	Mr. D. Hadziger, Novi Sad.
	Dr. P. D. Misic, Cacak.
	Dr. N. Velikonja, Zagreb.

Visiting Scientists.

Professor R. H. Hageman, Associate Professor of Agronomy, College of Agriculture, University of Illinois, U.S.A., left on 21st July after spending a year's sabbatical leave working in the Plant Physiology Section.

Dr. E. P. Breakey, Entomologist, Western Washington Experiment Station, Washington State University, made Long Ashton his headquarters between 21st April and 9th August, during a visit to Europe with Mrs. Breakey.

Mr. J. F. Bowen, Summerland Research Station, British Columbia, Canada, continued his work in the Cider and Fruit Juices Section during the year.

Students and Voluntary Workers.

Mr. C. F. Cresswell, M.Sc., Rhodes University, South Africa, completed his tenure of the Boots Scholarship in September, and left us to join the staff of Kings College, University of London. He was awarded the degree of Ph.D. (Bristol) for the thesis " The metabolism of nitrate, nitrite and hydroxylamine in higher plants ".

The Boots Scholarship for the two years from 1st October was awarded to Mr. J. C. Caseley, who had previously worked for two years in the Pomology Section as holder of a Ministry of Agriculture Scholarship. Mr. Caseley will continue, under the direction of Dr. Luckwill, his studies on herbicides, with particular reference to their effects on photosynthesis of fruit crops and to varietal tolerance.

Mr. C. E. C. Bartlett completed his two-year tenure of a Ministry of Agriculture Scholarship on 30th September and left to take up a post of Lecturer at the Essex Institute of Agriculture. He was awarded the degree of M.Sc. (Bristol) for the thesis " Factors affecting the quality of Cox's Orange Pippin apples ".

Mr. O. S. Peries, a postgraduate worker from the Horticultural Science Laboratories, completed his studies in September in the Plant Pathology Section under the direction of Dr. Bond and Mr. Marsh, and was awarded the degree of Ph.D. for the thesis " Studies on strawberry mildew ".

Mr. Lawrence Wilson, a research scholar from Trinidad, continued his investigations of zinc deficiency under the direction of Dr. Hewitt.

Mr. A. G. Biggs, Wye College (University of London), was awarded a two-year Ministry of Agriculture Scholarship and commenced his studies in the Pomology Section at Long Ashton in October. He will be working on problems of black currant culture.

Mr. C. Zaracovitis, a student from the Graduate School of Agriculture, Athens, commenced a period of study on 1st October in the Plant Pathology Section. He has been awarded a grant by the State Scholarship Foundation of Greece to enable him to spend up to three years in studies abroad. Mr. Zaracovitis is studying methods of assessing the effectiveness of fungicides.

Mr. A. V. Allen, Agricultural Officer, Christiana Area Land Authority, Jamaica, spent two weeks from 13th November working with Miss Leach, Domestic Food Preservation Section, on a course she had arranged for him in domestic pig-killing and curing, with visits to local industries connected with bacon-curing.

Mr. J. C. Bensink, a student at the State College of Tropical and Subtropical Agriculture, Deventer, Holland, received practical training in the fruit plantations from 1st to 22nd May.

Mr. M. A. Qadeer Choudhary of Pakistan spent two weeks from 4th September working in the Domestic Food Preservation Section. He was a Colombo Plan trainee studying chemical and applied microbiology of food at the National College of Food Technology, Weybridge, and was sponsored by the British Council.

Mr. G. R. Conway spent three weeks from 18th July training under the direction of Mr. Mapother and Dr. Morgan prior to taking up a Colonial Office appointment as Entomologist in North Borneo.

Miss Ayten Guvener of the Institute of Plant Protection, Ministry of Agriculture, Turkey, spent from 2nd October to 17th November working under the direction of Dr. Martin in the Analytical and General Chemistry Section, studying the effect of formulation on zineb deposits, during her tenure of a six-months' F.A.O. Fellowship for the study of pesticides residues in the U.K.

Mr. H. Kingman, a member of the staff of Imperial Tobacco Company, received a training course in plant nutrition under Dr. Bould, Nutrition of Fruit Plants Section, from the beginning of May to the end of August prior to his secondment to the Company's cigar leaf estate in North Borneo.

Dr. Yoshiharu Maruyama, Department of Biophysics and Biochemistry, University of Tokyo, who had been a Visiting Research Fellow at Cornell University, U.S.A., from 1959 to 1961, spent three months from 15th June working with Dr. Nicholas, Chemical Microbiology Section, under an arrangement with the British Council.

Mrs. C. Otaci of the Ministry of Agriculture, Ankara, Turkey, worked under Dr. Martin's direction in the Analytical and General Chemistry Section for two months from 1st March, on the micro-assay of mercurial and zineb fungicides.

Mr. C. J. P. Barnes left at the end of July on completion of his ten-month tenure of the Memorial Studentship in Cidermaking.

Mr. J. Upsher, a Sandwich Student from the College of Technology, spent from 15th May to 4th October studying microbiology with the Cider and Fruit Juices Section.

Mr. J. Henley of Messrs. Whiteways Cyder Co. Ltd. spent a further period in the laboratories of the Cider and Fruit Juices Section.

Mr. E. D. Evens, guest worker in Dr. Woodcock's laboratory, continued to give valuable voluntary assistance in the synthesis of organic compounds.

Social Activities.

The immensely improved amenities provided by the Refectory for social occasions have again been of great benefit to both staff and visitors to the Station. The Christmas Dinner and Party were both held on the same day—Thursday, 21st December—for the first time. After an excellent dinner organized by the Refectory Committee, the Recreational Club Committee converted the room into a concert hall by the addition of a stage, on which members of staff gave an entertainment during the evening party.

The Recreational Club continued its varied programme during the year. Talks were given on Swiss Alpine Plants by Mr. E. W. Hobbis, on the Archaeology of North Somerset by Mr. Gray Usher and Mr. D. Lilley, and on Driving by members of the Somerset Constabulary. Messrs. Coty Ltd. gave a demonstration of cosmetics to lady members. Visits were arranged to the Shakespeare Festival Theatre at Stratford-on-Avon, Lyegrove Gardens, the Austin motor factory at Birmingham, and the G.B. cavern on the Mendips. The Club made the arrangements for the annual interchange of visits between the National Vegetable Research Station staff, Wellesbourne, and the Long Ashton staff, and as Long Ashton was host this year an opportunity was given for our guests to see the new Refectory and Wallace Laboratory. The Music Group held three gramophone record concerts and a walk was arranged by the Photographic Section in the Limpley Stoke Valley. A treasure hunt was organized, finishing at Shepperdine, where competitors were entertained by Mr. and Mrs. Wagner. The annual Garden Party and Firework Display were well supported, and three dances were held in the Refectory in addition to the usual Christmas Party and Entertainment.

The Tennis Club organized a very successful Mixed Doubles Tournament among the staff, the winners being Miss Margaret Mealing and Mr. Peter Wilson, with Miss Dorothy Conibear and Mr. Lawrence Wilson runners up. Cups were presented to the winners by Mrs. Kearns at the Christmas Dinner, and their names are inscribed on the first shield to be affixed to the Bennett Memorial Silver Rosebowl. Only the Men's Team played in the Bristol League this season, finishing fourth in Group 7. In addition, the Club played twenty friendly matches, winning eleven and losing nine.

The Table Tennis Club continues as a popular activity, both during lunchtimes in the Header House and on one evening a week in the Common Room. A team was again entered in the Bristol and District Table Tennis League and just failed to gain promotion to the next division. Several friendly matches were played and an American Tournament was organized between Club members.

The Cricket Club had an enjoyable season although not too successful, partly owing to the decrease in playing members. Of the fifteen matches played only three were won, but most of the remainder were only lost by the odd run or wicket.

Members of the Rifle Club again enjoyed the hospitality of the Backwell Rifle Club for indoor shooting during the winter months, and used their own range in the summer for Club meetings. Winners of Club competitions were : I. T. Burke, N.R.A. Donegall Badge, Silver Spoon (spring handicap) ; T. W. Corke, Silver Spoon (autumn handicap) ; C. P. Lloyd-Jones and A. T. K. Corke, Bronze medals ; R. A. Webb won the pistol section. A statuette for annual competition, purchased with the help of a contribution from the President, was presented by him to the winner, C. P. Lloyd-Jones, after the Christmas Dinner.

Acknowledgments.

The Station is greatly indebted to the members of staff who made the occupation of the Wallace Laboratory so orderly. Sections occupied their allotted rooms in sequence, and furniture, equipment and services were made available at the correct time to ensure the minimum dislocation of work. Amongst those who gave so willingly of their help in undertaking the move, special mention must be made of Mr. E. W. Hobbis, Mr. G. H. Jones and their staff, Mr. A. A. Stenner, Mr. S. E. Cole and Mr. H. J. Jones and their staff, Dr. N. G. Morgan and Mr. J. H. Russell.

Thanks are due to staff for their ready co-operation in the organization of the Opening Ceremony, in particular to Mr. Greenwood, Mr. Leggett, Mr. Marsh and Dr. Martin. To Mrs. Swatridge and her Refectory staff especial thanks are due, as first-class catering arrangements added materially to the success of the occasion. Most grateful acknowledgment is made to Miss Simpson, Director's Secretary, for her patient assistance and considerable overtime expended in dealing with the voluminous paper work associated with the planning and equipping of the new buildings, and to Mr. Leggett for dealing with the numerous financial problems that arose. The National Fruit and Cider Institute contributed most generously towards the costs of the Ceremony and of the Staff Garden Party.

The Greenhouse Laboratories, the Biochemistry and Plant Physiology Laboratory, the Refectory and the Wallace Laboratory were designed and erected under the supervision of Eustace Button and Partner. To Mr. Button and Mr. Ackland the Station is greatly indebted for their sustained and personal interest in the building work in progress from 1954 to 1961. Their patient, skilled and constructive interpretation of the special specifications for laboratories greatly added to the satisfactory performance of the buildings. The contractors, Messrs. John Knox Ltd., provided high-grade workmanship. Our especial thanks are due to Mr. F. T. Jefferies, the Clerk of Works, whose vigilance ensured that every item was up to specification, and to Mr. F. Day, Colston Electric Company, who was responsible for the installation of the electrical work in all the post-war buildings.

Thanks are also due to staff who served on Station Committees, particularly their chairmen : Dr. Martin (Laboratory Services), Mr. D. L. Abbott (Library), Dr. Skerrett (Recreational Club), Dr. Woodcock (Refectory), and Dr. Luckwill (Welfare).

Mrs. Swatridge, Miss Ivory and their staff maintained their usual high standard throughout the year and catered for several staff functions. The pleasant atmosphere of the Refectory has made a major contribution to the well-being of the Station.

Mr. Greenwood again edited the Annual Report, and helped many members of staff with their manuscripts. Everyone is grateful for his able and kindly assistance.

THE OPENING OF THE WALLACE LABORATORY.

The completion of the Wallace Laboratory marked the culmination of a building programme that had been in progress since 1947. The Wallace Laboratory, the Refectory and the Glasshouse Laboratories were officially opened by Sir William Slater, K.B.E., F.R.S., on Thursday, 6th July, 1961. The guests numbered about 500 and included His Grace the Duke of Northumberland, Chairman of the Agricultural Research Council, and Dr. E. G. Cox, the Council's Secretary ; Sir Philip Morris, Vice-Chancellor of the University of Bristol, and Lady Morris ; Sir Wilfrid Anson, Chairman of the University Council, Captain D. M. Wills, Chairman of the Agricultural Committee ; Mr. H. G. Button and Mr. W. C. Moore of the Ministry of Agriculture ; the Directors of fellow research stations—Mr. F. C. Bawden, Rothamsted, Dr. J. Philp, Wellesbourne, Dr. T. Swarbrick, Mylnefield, Scotland, Mr. F. W. Toovey, Glasshouse Crops, and Dr. F. R. Tubbs, East Malling—; Mr. E. Llewelyn Harry, South-West Regional Director of the N.A.A.S. ; Mr. G. H. Moore and Dr. R. W. Bolland of the Bristol College of Science and Technology ; the architects, Mr. Eustace Button and Mr. James Ackland ; Governors and Members of the National Fruit and Cider Institute and members of the University and Research Station staff and their wives. The Rt. Hon. Earl Waldegrave, Parliamentary Secretary to the Ministry of Agriculture, Fisheries and Food, previously a member of the Agricultural Committee for many years, was unfortunately unable to be present.

Members of the Agricultural Committee and others were entertained to lunch in the Refectory, after which the official Opening Ceremony took place in a marquee erected on the lawn between the Biology Building and the Wallace Laboratory, when speeches were made by Captain Wills (Chairman), the Vice-Chancellor, Sir William Slater and Professor Kearns ; and a bouquet was presented to Lady Slater. The company then proceeded to the Wallace Laboratory, where Sir William unlocked the door and Professor Wallace unveiled a commemorative plaque on the applewood panelling of the entrance hall. Professor Wallace was presented with a book of photographs of the Research Station buildings.

The new buildings were then open for inspection by guests and tea was served in the Refectory. Exhibits included : (i) Selected publications by mem-

bers of the Long Ashton staff (Wallace Laboratory); (ii) The development of the Research Station land; (iii) Meteorology at Long Ashton since 1918; (iv) A photographic record of the construction of the Wallace Laboratory and Refectory (Header House); and (v) Cider-making past and present (Cider House). The programme contained a summary of building developments at the Station between 1948 and 1961, a description of the new buildings and a site plan and diagrams of the lay-out of the Wallace Laboratory and the Glasshouse Laboratories.

In the evening a Reunion Supper was held in the Refectory for all who had been members of staff or long-term research students at Long Ashton up to the year 1940, and on the following Saturday afternoon, 8th July, a Staff Garden Party took place, at which about 260 staff and their families were entertained to tea in the Refectory and a programme of entertainment was arranged by the Recreational Club.

Description of Buildings.

The Wallace Laboratory is a two-storey, T-shaped building with the long side 216 × 40 ft. sited north to south, and a short wing 80 × 40 ft. sited east to west. The working floor space is approximately 24,000 sq. ft., including a basement 65 × 40 ft. At the south end of the building is a tower which houses water tanks and pumps and is capped by an observation platform for meteorological recording. The roof space is insulated and covered with Bridgwater red tiles, and houses an air extraction system for thirty chemical fume chambers. There is also a Plenum heating system which compensates for some of the heat losses arising from fume extraction. The basement houses the main stores, electrical switch gear, and a steam heat exchange system which provides hot water for the services and ceiling heating of the building. The outer walls of the building are of Reformite reconstructed stone, matching the design of the Refectory.

The entrance hall has a terrazzo floor and the walls are panelled with apple wood veneer cut from one of the Knotted Kernel cider trees planted on the site in the very early days of the Cider Institute.

The Secretary and his staff occupy the ground floor of the west wing, with Analytical and General Chemistry above. The ground floor of the south wing accommodates the Pomology, Plantations and Photographic Sections; and Laboratory Services, part of the Analytical and General Chemistry and Organic Chemistry Sections and the Technical Typists' Room are on the first floor. The ground floor of the north wing has laboratories and offices for the Physical Chemistry, Willows and Statistics Sections, and the first floor accommodates Nutrition of Fruit Plants, Plant Constituents and part of Chemical Microbiology.

The furniture of the laboratories and offices is constructed of mahogany, sapele and teak woods; the floors are of teak blocks. The passages are floored with plastic tiles. The electric, gas, hot and cold water and drainage services are specially designed for easy maintenance and modification. An electrical lift is installed between the basement stores and the Laboratory Services Section on the first floor.

The Refectory was completed at the end of 1959 and is described in the Annual Reports for 1959 and 1960.

Bristol Evening Post

Sir William and Lady Slater and Professor Wallace at the opening of the Wallace Laboratory.

The Greenhouse Laboratories and the Biochemistry/Plant Physiology Laboratories were completed in 1956. The former, with its associated special-purpose rooms, is 300 ft. long and occupies 43,000 sq. ft. It has six separate greenhouses, each 72×34 ft. with a ridge height of 24 ft., constructed of a suspended Aluminex frame work, with side walls infilled with 2 ft. brick work. The houses from west to east are used respectively for propagation, Plant Nutrition (2), Pomology, Plant Pathology and Entomology. Each house communicates through a short glass corridor fitted with sliding doors to a Header House, laboratories and service rooms. The header house is 220×18 ft., forming a large open gallery on the southern half of the main building, the northern half being divided into laboratories, cold rooms and special purpose rooms with controlled environments. A suite of rooms for work on radio-active tracers is segregated at the west end of the building and has a special drainage system. The east end houses services for soil and plant preparation.

On the north side of this building, in line with the boiler house, is a laboratory block 87×32 ft. for Plant Biochemistry and Plant Physiology.

The main boiler house attached to the west end of the Greenhouse Laboratories contains three oil-fired, automatically controlled medium pressure McNeil steam boilers, which provide steam for the Greenhouse Laboratories, the Plant Biochemistry and Physiology Building, the Sand Preparation building, the heat exchange units for the heating systems and cooking appliances of the Refectory and for the Wallace Laboratory.

SUMMARY OF RESEARCH, 1961.

Pomology and Plant Breeding.

Plant Breeding.

Black currant bushes, propagated from selected seedlings raised from crosses made in 1947, and now included in a cropping trial, fruited for the first time during 1961. Some of the selections significantly outyielded the standard varieties and may be considered for extended trial if they maintain their present performance over the next few seasons. This trial is also being used for a statistical study of some components of yield. Of the two components so far studied the number of berries per strig showed a significant correlation with total yield ($r = +0.58$ on 22 d.f.) whereas mean weight of berries showed no correlation ($r = -0.05$ on 22 d.f.) Records of susceptibility to leaf spot (*Pseudopeziza ribis*) were taken from seedlings of the 1959 series of intervarietal crosses, and although none appeared completely resistant there were marked differences in the level of infection in different families.

Sixteen varieties of black currant were self pollinated as the first stage in the investigation of possible marker genes affecting seedling characters. Such marker genes, if discovered, could be used for estimating the amount of cross- and self-pollination which occurs under field conditions. Hypocotyl colour was observed to vary both within and between families, but further analysis will be necessary before this character can be used with confidence. Unfortunately, the germination rate from all the selfed families was low, ranging from 2 to 43 per cent. Various methods of improving the germination were tried, including treatment with gibberellic acid, which accelerated the rate of germination but only slightly increased total germination, and exposure to low temperature for various periods, which had no effect on germination rate.

Low concentrations of 1-naphthaleneacetic acid and gibberellic acid were shown to be capable of inducing parthenocarpy when applied in lanolin to emasculated and effeminated black currant flowers (p. 58). It is expected that these substances will assist breeding by enabling crosses to be made between black currants and other *Ribes* species with which they do not readily hybridize.

Cider apple seedlings from the 1947 series continue to come into cropping and, of a further 67 evaluated during 1961, 20 were retained for further observation. It is becoming obvious that, if required, it would be possible to produce a range of varieties from this batch of seedlings to parallel many varieties on the Recommended List. Such new varieties would have the advantage of being virus-free, large-fruited and moderately resistant to apple scab.

The variability in the seedling progeny of the apomictic *Malus hupehensis* and *M. toringoides* resulting from four different pollination treatments has been studied. The results show that, if uniform apomictic seedlings are to be produced, it is necessary to protect the mother trees from pollination by other *Malus* species. If cross pollination occurs the progeny will consist of a mixture of apomictic and hybrid seedlings (p. 68).

Growth Substances.

Fluctuations in the concentration of natural growth-promoting substances in the flesh of Cox's Orange Pippin apples were followed by bio-assay at weekly intervals throughout the life of the apple. The growing fruit showed two major peaks of total auxin which occurred at 5 and 12 weeks after petal fall. After harvest a sharp rise in auxin concentration was noted immediately after placing the fruits in cold storage. Subsequent to this the auxin curve followed closely those of respiration and nitrogen metabolism, reaching a maximum value at the time of the climacteric. The individual auxins found in the fruit flesh were chromatographically identical with those already described for the leaves and seeds of the apple. Indole compounds occurred in increasing quantity during the period of storage, but no evidence was obtained of indole auxins.

In further experiments (in collaboration with Physical Chemistry) on the fate of radioactive 1-naphthaleneacetic acid (NAA) applied to apple leaves it was found that losses previously attributed to volatility are, in fact, due to degradation by ultra-violet radiation. As much as 70 to 80 per cent of the NAA applied to the leaf surface may be broken down in this way. The main degradation product is a neutral compound with a U.V. absorption spectrum very similar to that of NAA itself. The possibility that this compound may play some part in the thinning action of NAA is being investigated.

In experiments to determine the most effective site of application of NAA for the control of fruit drop, local applications of this compound in aqueous solution were made to various parts of fruiting spurs of Miller's Seedling apple. NAA applied to the bourse and base of the fruit stalks delayed fruit abscission, but when the spur leaves only were treated, abscission was promoted. This effect was obtained only when lanolin barriers were placed on the petioles to prevent the spread of NAA by capillary movement in the surface tomentum.

In a small field trial with Laxton's Superb apples, the insecticide 1-naphthyl N-methylcarbamate ("Sevin"), and the gametocide, sodium α, β-dichloro*iso*butyrate, were compared with NAA as possible fruit thinning agents for apples. Both compounds reduced fruit number, and the gametocide also caused some damage to shoots and leaves. The greatest number of large fruits ($>2\frac{1}{2}$" diameter) was obtained from the control branches, but the trees are being kept under observation to study the effects on flower production in 1962.

Much damage was caused to the blossom of dwarf pyramid pears at Long Ashton by an air frost on the night of March 19/20, when most varieties were at the "green cluster" stage. This gave an opportunity to test the ability of sprays of gibberellic acid to induce parthenocarpic development of the fruit. The best treatment on Williams' (100 p.p.m. at full bloom) gave a four-fold increase in marketable crop, whilst on Laxton's Superb the marketable crop was increased $2\frac{1}{2}$ times by a spray of 50 p.p.m. applied at full bloom (p. 61).

In field trials with simazine (2-chloro-4, 6-bis (ethylamino)-1, 3, 5-triazine) for weed control in black currants, some damage was noted in bushes of Wellington XXX which had received 6 lb./acre in two successive seasons; the damage took the form of interveinal and marginal leaf scorch. Crop records could not be obtained because of extensive damage to the flowers by a frost on the night of March 19/20. The possibility of using simazine and

neburon (N-butyl-N′-(3,4-dichlorophenyl)-N-methylurea) for weed control in cutting beds of black and red currants was investigated. Simazine at 2 lb./acre, either incorporated in the soil before planting, or sprayed on after planting, gave good weed control and, although some symptoms of leaf damage were seen, by the end of the season the plants were equal in size to those from hand-hoed control plots. Neburon proved ineffective as a weed-control agent in this experiment.

To control weeds and long grass around the bases of established apple trees, experiments have been carried out with a range of quick-acting and residual herbicides, applied singly and in various combinations. The most effective treatments were atrazine (2-chloro-4-ethylamino-6-isopropylamino-1, 3, 5-triazine) at 10 lb./acre and mixtures of simazine or diuron (N-(3, 4-dichlorophenyl)-N′N′-dimethylurea) at 10 lb./acre with either paraquat (1, 1′-dimethyl-4, 4′-dipyridylium-dimethyl sulphate) or amitrole (3-amino-1, 2, 4-triazole) at 4 lb./acre.

In a field trial with Cambridge Vigour and Favourite strawberries, diquat (1,1′-ethylene-2,2′-dipyridylium dibromide) was applied alone and in combination with simazine in the early winter with the combined object of killing weeds and destroying the strawberry foliage which carries overwintering mycelia of strawberry mildew (*Sphaerotheca humuli*). Timing of the sprays proved critical : application in October caused severe damage to the plants, whilst application in November was much less damaging.

Weed control trials in gooseberries, apples, plums and pears which were started in 1960, using a wide range of modern herbicides, have been continued during the past year, and further investigations have been made into varietal differences in tolerance to various herbicides, using sand cultures.

Physiology of Fruit Plants.

Observations were continued on the growth and cropping of four varieties of dessert apple at Lackham Farm Institute, Wiltshire.

Three varieties of apple were grown in controlled environment chambers under four different winter temperature regimes. Differences were noted in time of bud break, bud development and flower production, but the treatments did not appear to affect the ultimate yield of fruit.

In an experiment with one-year-old potted trees of Worcester Pearmain grown as two single stems, removal of all lateral buds along either stem before bud break delayed fruit drop from the apical cluster by one week. When the buds were removed from both stems fruit drop was delayed by nearly four weeks, but fruit size was reduced because of lack of foliage. Fruitlets from severely pruned and control trees of Laxton's Superb apple were removed at intervals during the growing season and fixed for subsequent determination of cell numbers and sizes.

An investigation was started in 1959 into the effects of the presence of flowers and young fruitlets on the differentiation of flower primordia for the following year in the strongly biennial apple variety Emneth Early. It has been found that complete deblossoming of " on-year " trees leads to excessive fruit-bud differentiation on one-year wood, but that when the trees are defruited three weeks after bloom, the bulk of the fruit buds are formed on the bourse shoots. Later defruiting leads to the differentiation of fewer fruit-

buds, but there is no sharply defined critical date beyond which defruiting is ineffective in stimulating fruit-bud differentiation.

In co-operation with Chipping Campden Research Station a long-term field trial has been planted in Worcestershire to investigate the effect of source of bud-wood and rootstock on the canning quality of Victoria Plums.

Studies of pollen-tube growth in the styles and ovaries of apple flowers have been hampered by the excessive variability encountered between individual flowers, even when taken from the same cluster. To overcome this, a unit style technique has been developed whereby the growth rates of four different pollens, plus a marker, can be compared on a single flower. Preliminary experiments comparing the pollen-tube growth rates of various varieties in the styles of Cox's Orange Pippin suggest that Egremont Russet is often superior to other pollinators. A study of the factors affecting the female fertility of apple and pear flowers has commenced. Fertility is assessed by examination of the differentiated embryo sac to determine the length of its receptive period. It has been shown that the application of nitrogen to the tree during the previous summer can considerably extend this receptive period, either by delaying the disorganization of the unfertilized sac or by stimulating the production of secondary embryo sacs to replace the ageing primary sac.

Studies on fruit quality and storage life of Cox's Orange Pippin in relation to cover crop and manurial treatment were continued during the past year, using fruit samples from the apple manurial trial at Efford Experimental Horticulture Station. The results of this study have been incorporated in an M.Sc. thesis by Mr. C. E. Bartlett entitled "A study of some factors affecting the quality of Cox's Orange Pippin apple".

Rootstocks and Propagation.

The elimination of "chlorotic leaf spot", "*platycarpa* dwarf" and "scaly bark" viruses from 30 clones of 20 dessert, culinary and cider apple varieties has been achieved by a combination of heat treatment and tip propagation. The clones that have been successfully cleared of these viruses are now being multiplied vegetatively for further testing, for field trials to assess orchard performance and for eventual distribution to growers. To examine the effect of latent virus infection on Bramley's Seedling a small trial has been planted in which the performance of scions from a normal commercial source will be compared with that of scions from the original tree, which is free from all known viruses. The search for healthy clones of apples has been continued and particular emphasis has been placed on the virus-testing of scions from very old trees. In spite of the almost universal infection of the varieties examined, no evidence of natural spread in the nursery or orchard has been obtained. Tests have shown that some apple viruses can pass into a rootstock from an inoculation bud or bark chip even when they have been in contact for only two days; this emphasizes the dangers of current nursery practices such as reworking rootstock failures, or returning budded rootstocks to the stoolbed (p. 71).

Further observations have been made on the reaction of a wide range of varieties and species of *Malus* to the viruses that are commonly carried in latent form in commercial apple varieties. It is now thought that these viruses are

responsible for the incompatibility previously noted between the apomictic rootstocks *M. theifera* and *M. Sargentii* and the varieties Cox's Orange Pippin, Worcester Pearmain and Lord Lambourne.

Twelve perry pear varieties double-worked on Quince A stocks with a Beurré Hardy interstock have grown and fruited well and, at 6 years old, have shown no incompatibility symptoms. By contrast, the unions of three varieties with an interstock of Rock, a perry variety previously thought to be compatible, broke easily when tested at 5 years old.

In a nursery trial the perry variety Blakeney Red was compared with four other varieties as a stembuilder for standard perry trees. All proved unsuitable because of severe virus infection.

Variety Trials and Cultural Experiments.

Small plots have been established to compare the cropping of apples pruned as pillar trees and as dwarf pyramids ; two varieties, Cox's Orange Pippin and Worcester Pearmain, are being used on the four rootstocks M.II, M.VII, MM.104 and MM.106. A second experiment includes trees of Cox and Worcester trained as pillars on M.II, M.VII, M.XVI, M.25, MM.109 and Crab C rootstocks. In co-operation with the Entomology Section a new plot was planted in 1960/61 to establish apples in hedgerow form. This plot will include trees trained as dwarf pyramids, pillars and free palmettes. The last shape is one that is now being widely used in N. Italy for the growing of apples, pears, peaches and apricots.

The loganberry clone LY.59 still shows itself capable of cropping heavily. During 1961 two further clones (L.463/3 and L.460/2) have been propagated from mother plants supplied by East Malling Research Station. These will be planted in the spring of 1962 together with young plants of LY.59 from the original stock, for purposes of comparison.

Cider and Perry Varieties.

Work on the pomological description and illustration of the principal varieties of cider apple has been continued (p. 77), and similar work on the perry pears of Gloucestershire and the West Midlands has been completed (p. 86). As a result of further information on the orchard behaviour and culture of perry pears, the list of varieties recommended for planting has been amended (p. 92). During the year eleven enquiries from growers have been dealt with : they concerned the planning of new orchards, with particular reference to varietal combinations that afford adequate cross pollination and a short harvesting season that permits maximum utilization of the sward.

See also Nos. 13, 14 and 51 in *Publications 1961*, pp. 53-55.

Plant Nutrition : Fruit.

Field Experiments.

The long-term nutritional experiments at Long Ashton (apple and pear), and the N.A.A.S. Experimental Horticulture Stations at Efford (apple, pear and black currant) and Luddington (plum and black currant) have been continued. An account of the first phase of the apple cover crop experiment at Long Ashton has been submitted for publication. The major effects on growth, crop yield and leaf nutrient status, in the first phase, were due to cover

crops. Nitrogenous fertilizer had significant effects in combination with timothy and rye-grass, but phosphate and potassic fertilizer had no significant effects on growth or crop yield. Clover and natural sward had the least deleterious effect on tree growth and gave the highest yield of fruit. Timothy and rye-grass severely restricted tree growth and crop yield. This was largely due to competition for nitrogen, which was clearly reflected in a reduced nitrogen concentration in the leaves of the trees.

At Efford, nitrogen effects on apple due to covers (noted in 1960) were confirmed by leaf analysis. The percentages of nitrogen in leaf dry matter were : Cover = 2.12 ; No cover = 2.66, for Cox's O.P., and Cover = 2.53 ; No cover = 3.04 for Worcester leaves sampled in August. Potassic and phosphatic fertilizers had significant effects on leaf potassium and phosphorus. Covers enhanced leaf potassium in both varieties.

At Luddington, nitrogen effects on plum due to cover were noted in 1960 and 1961 ; these were confirmed by analysis of leaf samples taken in 1960. The percentages of nitrogen in leaf dry matter were : Cover = 2.08 ; No cover = 2.43, for Victoria, and Cover = 1.90 ; No cover = 2.29 for Warwickshire Drooper. Potassic fertilizer had a significant effect on leaf potassium. The variety Victoria cropped heavily for the first time in 1961, but the results have not yet been analysed.

In the black currant nutrition experiments at Luddington and Efford enhanced crop yields have been given by irrigation. At Luddington, following irrigation, bushes have responded to nitrogenous fertilizer (var. Baldwin) and potash (var. Mendip Cross). Previously neither variety had responded to fertilizers, because of the adequate leaf nutrient status of bushes on all plots. At Efford, significant responses have again been obtained from phosphatic and potassic fertilizers, but high nitrogen rates have depressed the yield of Mendip Cross. These responses were associated with deficient levels of phosphorus and potassium but adequate levels of nitrogen in the leaves of the bushes in 1960. The second season's results from the experiments on the time of application of nitrogenous fertilizer to strawberries, made in collaboration with Mr. F. A. Roach of the N.A.A.S., showed no significant effect of treatments on crop yield. Analyses showed that the leaf-nitrogen status of plants on control plots (no nitrogen) was above the sufficiency level.

Pot Experiments.

Two comprehensive sand culture pot experiments (N × P and K × Mg) with raspberry, var. Lloyd George, were completed in 1961. In both experiments leaf analysis and cane growth in 1960 were related to crop yield in 1961. In addition to significant main effects on yield and leaf composition, highly significant interactions between nutrients were obtained. Thus in the N × P experiment it was shown that a particular leaf phosphorus value could be associated with varying crop yields, depending on the leaf nitrogen. Similarly in the K × Mg experiment the optimum level of one nutrient depended on the level of the other. Bearing in mind these interactions, high crop yields were associated with the following leaf-nutrient values in samples of laminae taken from the mid-third region of non-fruiting canes at the end of June : nitrogen, 3.0% ; phosphorus, 0.25% ; potassium, 1.5% and magnesium, 0.35% in dry matter. It will be noted that raspberry has a much higher

requirement than strawberry for magnesium (Annual Report for 1960, p. 27) and a somewhat higher nitrogen requirement.

Experiments were continued on the effects of the time of application of nitrogen to maiden apple trees (var. Lord Lambourne) grown in sand culture. Blossom records were taken (1961) on a series of trees given additional nitrate nitrogen over short periods in 1960. The largest number of blossoms was produced by trees given extra nitrogen in June 1960 ; these trees also made the most new extension growth. It was confirmed that where nitrogen, added later in the season, had induced secondary extension growth, this secondary growth carried predominantly vegetative buds. However, trees receiving late nitrogen, but not making secondary growth, carried more blossoms and flowered earlier than control trees. The tendency for trees to make secondary extension growth was apparently related to their initial nitrogen status. Further experiments comparing nitrogen status with time of application of extra nitrogen were carried out in 1961 and the results will be assessed in 1962.

Sub-irrigation sand culture trace-element experiments with strawberry in 1960 resulted in the death of many plants shortly after fruiting. It was found that the nutrient solution had become alkaline (pH 7.7). This effect was due to the sand and did not require plant growth to produce the change ; the sand caused deposition of phosphate and several trace elements. Strawberry plants made continuous healthy growth in 1961, when the pH was regulated with nitric acid. Extension of the experimental period of growth has shown that symptoms of trace element deficiency or excess, originally slight, become progressively more severe, and that the range over which trace element supply can be considered adequate for plant growth is more restricted than had previously been supposed.

A preliminary experiment with raspberry has shown that the quantity of trace elements contributed by small single canes has only a short-lived effect ; this makes the use of this material feasible for trace element studies.

In collaboration with the Physical Chemistry Section experiments have continued on the utilization of iron chelates by plants (p. 34).

Laboratory Investigations.

A large number of leaf samples from pot and field experiments have been analysed for major and trace elements.

The Nessler method for the determination of nitrogen as ammonia has been studied extensively. It has been confirmed that the colour produced is very sensitive to the final alkalinity. By neutralizing the Kjeldahl digest with alkali (to bromocresol green) before adding the reagents, the method was found to be reliable, versatile and suitable for small samples.

Difficulties have been encountered in the application of the paper chromatographic method of assaying trace elements to dry plant ash containing high amounts of phosphate or silica, both of which lead to low values for iron. Phosphate interference can be overcome by the use of zirconyl chloride but a wet ashing procedure is needed with materials high in silica.

A study of the paper chromatography of a wide range of complexone acids and their ferric iron chelates has been completed and submitted for publication.

Preliminary studies have been made on atomic absorption spectrophotometry for the determination of nutrient elements in plant ash material.

There are indications that this technique will be of value for the determination of zinc. Work is in progress on the determination of other elements.

See also Nos. 3, 4, 5, 6, 7, 31 and 32 in *Publications, 1961*, pp. 53-55.

Organic Chemistry.

Chemical Structure—Fungicidal Activity.

The thirteen *n*-alkyl guanidine acetates prepared in 1960 have now been tested against conidia of *Venturia inaequalis*; maximum fungistatic activity was associated with a chain length of 12-15 carbon atoms. *Nectria gaiigena* and *Podosphaera leucotricha*, when tested with selected members of the series, appeared to be more tolerant, though the *n*-dodecyl homologue was again most active against both fungi. The presence of the guanidino residue would seem to be critical in these compounds, since a series of *n*-alkylamine hydrochlorides prepared and tested against *V. inaequalis* for comparison was found to be less active, maximum fungistatic activity, moreover, being associated with a rather longer carbon chain. Several members of the related acid amidoxime series and the derived acid amidines have been prepared for testing.

The investigation into the fungitoxicity of dinocap ("Karathane") (2-1′-methylheptyl-4,6-dinitrophenyl crotonate) and related compounds has continued. A paper describing the preparation of fourteen 6-alkyl-2,4-dinitrophenyl esters has been accepted for publication; four 2,4-dinitro-1-naphthyl esters have also been prepared for comparison. Attempts to prepare 2-hexyl-4-nitro-1-naphthol have been hampered by 2-hexyl-1, 4-naphthaquinone formation at each stage, and by failure to demethylate 2-hexyl-4-nitro-1-methoxynaphthalene in the final step. Using ethanolic tetraethylammonium hydroxide it has been shown that of 30 esters tested, those showing some anti-mildew activity (e.g. dinocap, 6-*n*-pentyl, hexyl or heptyl 2,4-dinitrophenyl crotonates) have slower hydrolysis rates than less active compounds (e.g. 2,4-dinitrophenyl and 2,4-dinitro naphthyl esters). Methods for the preparation of 2,4-dinitro- and 6-alkyl-2,4-dinitrophenoxy propionic acids are being examined.

Of twelve 2,4-dinitrophenylhydrazones prepared, only three showed any promise against *V. inaequalis*, and none was as active as dinocap when tested against apple mildew in a greenhouse assay.

Fungal Metabolic Studies.

The investigation of the metabolism of chlorophenoxyacetic acids by *A. niger*, using a replacement culture technique, has been continued. The unknown fourth acidic product from 2-chlorophenoxyacetic acid has now been identified as *o*-hydroxyphenoxyacetic acid; this represents the first example of fungal replacement of chlorine by hydroxyl. The major product from 2,4-dichlorophenoxyacetic acid has been shown to be 2,4-dichloro-5-hydroxyphenoxyacetic acid. It is closely associated on paper chromatograms with another acidic product which has so far not been identified, though obvious possibilities such as 3- and 6-hydroxy-2,4-dichlorophenoxyacetic acid and 4-chloro-2-hydroxyphenoxyacetic acid have definitely been excluded.

Attempts to apply the Baeyer-Villiger per-acetic acid oxidation to the

synthesis of 1-hydroxy-2-naphthyloxyacetic acid have been unsuccessful. It appears that the lability of this acid, which is of interest as a possible fungal metabolite of 2-naphthyloxyacetic acid, and also as a potential plant growth regulator, may make its synthesis impossible.

See also Nos. 11, 21, 22 and 52 in *Publications, 1961*, pp. 53-55.

Physical Chemistry.

Using ^{14}C-labelled 1-naphthalene acetic acid (NAA), work has been continued, in collaboration with the Pomology Section, on the uptake and metabolism of this compound by apple leaves in relation to fruit thinning and pre-harvest drop. Following absorption, decarboxylation of NAA did not occur, but 90% of the NAA was metabolised within a few hours to give one neutral and one acidic water-soluble derivative. Both compounds lacked auxin activity in the *Coleus* petiole abscission test and in the *Avena* mesocotyl test. Ultra-violet radiation (U.V.) degraded NAA with the loss of the carboxyl carbon and the formation of a neutral compound inactive in auxin tests and with a U.V. absorption spectrum similar to that of NAA. U.V. radiation rather than volatility was considered to be responsible for the loss of NAA on the leaf surface. The significance of this finding in apple thinning with NAA is under study.

Work involving the use of ^{14}C-labelled iron chelates was continued in collaboration with the Plant Nutrition Section. After growing tomato in water culture for ten days with ^{14}C-labelled Fe-EDTA, nearly all the radioactive constituents were recovered by using columns of cation exchange resins. The radioactivity was shown by chromatographic and electrophoretic techniques to be associated with EDTA itself, and with a very similar compound. Following the introduction of ^{14}C-labelled Fe-EDTA into bean plants via the cut stem, a complete recovery of ^{14}C was obtained from plants grown in the shade, whereas up to 60% was lost from those grown in sunlight. The treated plants grew normally but the untreated controls became chlorotic. Tests were made on the absorption of ^{14}C-labelled Fe-EDTA by tomato root tips grown in the dark in tissue culture. Iron was absorbed, with increases in dry weights compared with controls, but very little absorption of EDTA occurred. It was tentatively concluded, from these and similar studies, that plants may utilize the iron from the iron chelate without breaking down the EDTA itself.

Assistance with the preparation and assay of radioactive solutions has been given to Analytical and General Chemistry (^{64}Cu, ^{35}S and ^{203}Hg); Plant Pathology (^{14}C and ^{35}S); Plant Constituents (^{14}C); Chemical Microbiology (^{58}Co and ^{59}Fe).

The study of the ageing of aqueous solutions of surface-active compounds using the oscillating jet method was continued. Work on the behaviour of commercially pure sodium di-(2-ethylhexyl) sulphosuccinate (DEHS) and sodium dinonyl sulphosuccinate (DNS) in waters of different hardness was completed (p. 124). Whilst the equilibrium tension of DNS at 0.025% in soft (7 p.p.m. Ca) water at 20°C was 24 dynes/cm.—about 5 dynes/cm. lower than the corresponding value in distilled water—its dynamic tension was still above 72 dynes/cm. for at least the first 1/20 sec. No difference in rates of ageing were observed between solutions prepared in distilled water and in Permutit-demineralised water. The behaviour of commercially pure sodium di-(*n*-octyl)-

sulphosuccinate and sodium bis-(tridecyl)sulphosuccinate was also investigated. The equilibrium tension of the latter in distilled water at 20°C was below 30 dynes/cm. even at concentrations as low as 0.005% ; its rate of ageing, however, at concentrations up to 0.05%, was very much slower than that of DEHS and DNS at comparable concentrations. These effects again demonstrate the inadequacy of equilibrium tension values for assessing surface activity immediately after surface formation.

The purification of several of these sulphosuccinates was attempted, the extent of purification being assessed by the form of their equilibrium tension-concentration curves and by their U.V. absorption spectra. Purification appeared to have only a slight effect on their dynamic tension values. The electrical conductivities of solutions were determined, to provide additional information on micelle structure and behaviour.

Following recent work in the U.S.A., tests were made with an orifice of new design ; the results suggested that there was little difference between the experimental values obtained with orifices of different types.

See also No. 46 in *Publications, 1961,* pp. 53-55.

Analytical and General Chemistry.

Work was continued on the mode of action of fungicides, on insecticide and fungicide spray deposits and residues, and on the chemistry of plant cuticles in relation to the deposition, retention and penetration of chemicals and to invasion of fungi.

Mechanism of Fungicidal Action.

The uptake, from aqueous solutions, of captan (*N*-trichloromethylthio-*cyclo*hex-4-ene-1,2-dicarboxyimide) by twelve species of fungi and of six of its N-trichloromethylthio analogues by two species was examined *in vitro*. The spores accumulated large amounts of the compounds, but uptake was unrelated to spore surface area or oleyl alcohol/water partition coefficients. Uptake was temperature dependent and was reduced in the presence of enzyme inhibitors ; no uptake was shown by dead cells. Uptake was therefore not solely a physical process but was governed by cell metabolic activity. Earlier observations that reactions with sulphydryl groups in the cells were concerned in the toxic process were confirmed, and work was begun on the levels of thiol compounds present in a number of fungal species. Experiments using root application of the radio-active (^{35}S) compound showed that captan was translocated only to a slight extent in the broad bean plant. A review of the work on captan is given on p. 110.

The effects of temperature and concentration on the uptake of copper (^{64}Cu) by fungal spores were examined. Marked differences were found between *Alternaria tenuis* and *Neurospora crassa* in their ability to bind copper. The radioactive copper accumulated by *A. tenuis* was easily removed by mineral acids or ethylenediaminetetraacetic acid and rapidly exchanged with non-radioactive copper ; these effects were shown only to a limited extent by *N. crassa*.

Work was commenced on the toxic action of mercury (^{203}Hg), and on the uptake of dodine-acetate (*n*-dodecylguanidine acetate) by fungal spores.

Spray Deposits and Residues.

The use of gas chromatography to determine residual amounts of chlorinated hydrocarbon insecticides was investigated with a view to the development of a rapid method of analysis free from the interference from plant constituents often met in conventional colorimetric methods. Hydrogen flame ionisation and photoelectric detection systems were examined but appeared to be less suitable than the electron capture method. An apparatus using electron capture detection is under construction.

Work was completed on a colorimetric method for the determination of deposits of the new spray material 2-(1′-methylpropyl)-4,6-dinitrophenyl-$\beta\beta$-dimethyl acrylate. A method was devised for mixed deposits of captan and dinocap (2-(1′-methylheptyl)-4,6-dinitrophenyl crotonate), but some difficulty was met in the determination of captan owing to the erratic behaviour of the pyridine-tetraethylammonium hydroxide reaction. A micro method was worked out for zineb (zinc ethylene-1,2-bisdithiocarbamate) and used to assess the effects of the incorporation of wetters in zineb suspensions applied to black currant and coffee leaves. Work was commenced on the formulation of sulphur sprays with a view to improved application to black currant for the control of the Big Bud mite. The standardization of alumina used to remove interference in analytical methods for deposits was continued and an alternative method for the rapid combustion of plant material in the determination of mercury was also examined. Soils were assayed for DDT on behalf of the National Vegetable Research Station.

Investigations were continued on the contamination of crops by mercury compounds used for disease control. Bramley apple trees were given one to five full-coverage hand applications of phenylmercuric acetate (0.005% Hg) with added wetter and five applications without wetter. The highest contamination of the fruits at harvest resulted from the five applications with wetter and amounted to 63 μg Hg/fruit (0.24 p.p.m.), of which 22 μg occurred in the flesh. The value of 0.24 p.p.m. exceeded the unofficial maximum permissible limit (0.1 p.p.m.) and the level of contamination normally found in commercially sprayed apples (about 0.06 p.p.m.). Lime leaves sent by the Department of Agriculture, Zanzibar, were analysed for mercury deposits in work on the control of the wither-tip disease caused by *Gloeosporium limetticola* ; good concordance was obtained between assessments of deposits using Saturn Yellow as a fluorescent indicator and mercury values determined analytically. Carrots, turnips and potatoes from field plots treated with inorganic mercurials were assayed on behalf of the West of Scotland Agricultural College ; the carrots and turnips contained up to 0.03 p.p.m. Hg. the potato tubers showed trace amounts located only in the peel, but definite contamination was found in the potato roots. The translocation of mercury, applied as phenylmercuric acetate, from leaves was further examined ; movement was found from broad bean leaves into the roots and seeds in pod and from potato leaves into the roots and tubers. Tree bark samples were analysed for mercury for the Plant Pathology Section in connection with the control of canker. Some of the investigations on mercury are described more fully on p. 106.

The Cuticles of Plants.

An enzymic process (Pektolase at pH 3.5 and 37°C) was used as an

alternative to the chemical method (refluxing with oxalate solution) for the separation of cuticular membranes from leaves and fruits. Comparisons were made of the development of the waxes and cutin in the leaves of apple rootstocks and seedlings grown in the open and under glass. The levels and composition of the waxes obtained separately from the upper and lower surfaces of apple and black currant leaves and the wax of coffee leaves were examined in relation to the retention of fungicides, and work was commenced on the quantitative determination of non-cutin components of cuticular membranes in connection with the penetration of spray chemicals and fungi.

The cuticles of Cox apple fruits from a fertilizer experiment were analysed on behalf of the East Malling Research Station, and the cuticles of strawberry leaves were fractionated for work in the Plant Pathology Section on varietal susceptibility to disease. Apple pomace was investigated as a source of cutin ; the cutin acids obtained from it suppressed the germination of mildew spores. Further work was done on the cuticles of lime leaves, sent from Zanzibar, in relation to infection by *G. limetticola*. No differences were found between the waxes of young susceptible and older resistant leaves, but the cutin of the young leaves was one-third of that of the older leaves. The surface waxes permitted normal germination of the spores of the fungus, but the absorbed waxes and the cutin acids derived chemically from the cutin suppressed germination. The production of waxes and cutin in the cuticles of Dove (susceptible to scab) and Dabinett (resistant to scab) cider apples was followed during the growth of the fruits ; small differences only were found in the contents of waxes, but the cutin in the Dove was much lower than that in the Dabinett fruits. The extent to which cutin is formed in the cuticle appears to be an important factor in determining the degree of resistance to a fungus. Whether cutin acids are liberated during fungal penetration is unknown ; work was commenced in collaboration with the Pathology Section on the ability of fungi to hydrolyse cutin.

Attention was given to the chemistry of cutin, of which little is known. The cutin acids liberated from the cutin obtained from large batches of Cox apple leaves and Cox and Dabinett apple fruits were fractionated ; two components were isolated in pure crystalline form and characterized as trihydroxyoctadecanoic acid (m.p. 98-9°C) and dihydroxyhexadecanoic acid (m.p. 76-7°C). Two more compounds and an oil, not yet resolved, were also obtained. The acids appeared to be identical with those recently obtained by a South African worker from the cutin of leaves of *Agave americana* L. Further work is planned to ascertain to what extent cutin is constant in composition in plants of different species. A fuller account of some of the cuticle investigations is given on p. 114.

See also Nos. 36, 42, 43, 44 and 45 in *Publications, 1961*, pp. 53-55.

Plant Biochemistry.

Studies of the photochemical activities of isolated chloroplasts have been continued. The finding (Annual Report for 1959, p. 44) that the rate of reduction of nicotinamide-adenine dinucleotide phosphate (NADP) by illuminated chloroplasts in the presence of a specific leaf protein is strongly stimulated when the reduction is coupled to the phosphorylation of adenosine diphosphate has recently been questioned. An extensive re-examination of

the reaction has excluded the possibility that the effect is due to uncontrolled change of pH and has confirmed the initial interpretation. Further confirmation has since come from workers in other laboratories.

It was shown (Annual Report for 1960, p. 32) that diquat and paraquat, substances active as defoliants only when the treated plants are illuminated, are also active catalysts of " cyclic photophosphorylation " by illuminated chloroplasts. In air hydrogen peroxide is produced in amounts stoicheiometric with the inorganic phosphate incorporated into adenosine triphosphate (ATP). Arising from this, other known catalysts of photophosphorylation have been examined for their possible effects on metabolism, using the green alga *Chlorella* as test organism. The most active of these catalysts is N-methylphenazonium methosulphate (PMS) : this substance was found to inhibit photosynthesis and growth of the alga at low concentrations. Measured manometrically, oxygen production in the light was half inhibited at 10^{-6} PMS. An inhibition of this order implies that PMS is as effective as any known inhibitor of photosynthesis. Exhaustive washing of PMS-treated cells resulted in complete reversal of the inhibition.

It is well known that PMS exposed to actinic light in air is rapidly photoxidized, the principal product being the 4-keto derivative, pyocyanine. This compound has been shown to be as effective as PMS in catalysing photophosphorylation by isolated chloroplasts. With whole cells of *Chlorella*, however, neither purified pyocyanine nor the photoxidation products of pre-irradiated PMS had any effect on oxygen production. There is therefore at present no evidence that this effect of PMS is related to its activity as a catalyst of photophosphorylation ; the mechanism of the inhibitory action is being studied further.

See also No. 20 in *Publications, 1961*, pp. 53-55.

Plant Physiology.

Work on the nitrite reductase system of vegetable marrow has been continued. This system catalyses the quantitative conversion of nitrite to ammonia when benzyl viologen is used as the electron donor or as a cofactor in the presence of reduced co-enzyme II ($NADPH_2$). The apparent dissociation constant (K_m) for the overall system for reduction of nitrite is 4.75×10^{-6} ; this low value probably accounts for the rare appearance of nitrite as an intermediate product of nitrate assimilation *in vivo*. With $NADPH_2$ as primary electron donor and with catalytic amounts of benzyl viologen, rapid and quantitative reduction of nitrate to ammonia was also observed. The natural cofactor involved in nitrite reduction has not been identified, but flavin mononucleotide, flavin adenine dinucleotide, nicotinamide adenine dinucleotide and nicotinamide adenine dinucleotide phosphate have been excluded. The activities of nitrate and nitrite reductases observed *in vitro* are adequate to account for the normal rates of nitrate assimilation by intact plants. No evidence of metal requirements has been obtained from the study of inhibitors : plants deficient in manganese or iron have shown both normal and relatively low activities ; the significance of these results is not yet known.

Hydroxylamine reductase is also present in extracts having nitrite reductase activity. When compared under identical conditions, the rate of

reduction of nitrite to ammonia is greater than that of hydroxylamine. The levels of hydroxylamine used are not inhibitory and the apparent K_m is about 5×10^{-4}. Hydroxylamine has no appreciable effect on the rate of reduction of nitrite to ammonia but nitrite severely inhibits hydroxylamine reduction. These results suggest that free hydroxylamine is not a direct intermediate in nitrite reduction to ammonia but may be converted first to another compound which is also produced during nitrite reduction.

The essential nature of cobalt for nitrogen fixation by *Alnus* and *Casuarina* root nodules has now been demonstrated by work continued in collaboration with Dr. G. Bond of the University of Glasgow. Cobalt-deficient plants contained 0.3–0.6 p.p.m. Co in roots and 0.02–0.09 p.p.m. in nodules and leaves. Plants given cobalt contained 6–8 p.p.m. Co in nodules, 4–13 p.p.m. in roots and 1–2 p.p.m. in leaves, and fixed 8 times as much nitrogen as the deficient plants.

Work on the effects of zinc supply on leaf development in a number of plant species is continuing. In tomato and tobacco, zinc deficiency resulted in the suppression of all primordia after the first six. Limited expansion of the first two primordia occurred, whilst the remainder showed no appreciable cell expansion, though cell division continued for some time before growth ceased. Protein synthesis continued in some plants up to the cessation of cell division. In normal plants cell division continues at a regular rate for longer periods, and up to seven primordia are in a state of exponential growth at one time. On renewing the supply of zinc, recovery from deficiency was seen first in chloroplasts and nuclei of the first two leaves, which could not, however, make renewed growth, though cell division recommenced in younger primordia and was followed by cell expansion.

Mr. A. J. Abbott returned to Long Ashton in October after working for two years with Professor Yemm in the Botany Department. He there studied the growth and metabolism of the cultured excised pea root and deviations from the normal occasioned by metal deficiencies.

Using root material from preliminary cultures, uniform reproducible root cultures were obtained without soluble reserves from the seed. During 10 days of culture a linear growth rate was observed to result from a gradual decline in the rate of division of an increasing number of meristematic cells. In the normal cultured root, net protein synthesis was at a maximum in the late stages of expansion and ceased in fully expanded cells. The concentration of soluble amino acids was highest in the meristematic tissue, in which respiratory activity is lowest. The complement of deoxyribonucleic acids in the cell continued to increase after expansion was complete, but there was a 40% decrease in the ribonucleic acids from the time of early cell expansion to early maturation, and thereafter a slight increase. The analytical data agreed closely with those obtained from autoradiography of roots fed with tritiated nucleotides.

Withdrawal of iron from the medium caused an abrupt cessation in cell division in the apex, accompanied by more than 100% increase in the soluble amino acids and a considerable increase in the level of protein synthesis and oxygen consumption in the apical region.

See also Nos. 27, 28, 29 and 30 in *Publications, 1961*, pp. 53-55.

Chemical Microbiology.

Nitrogen Fixation. A technique has been developed in collaboration with the M.R.C. Radiotherapeutic Unit, Hammersmith Hospital, for using radioactive nitrogen (^{13}N) to study nitrogen fixation in cell-free extracts of *Azotobacter vinelandii* (OP). Nitrogen-13 is readily incorporated into particle-free extracts of the bacteria but the addition of cell-particles and boiled culture medium (in which the organism was grown) enhances the fixation. The cell-particles contain the active hydrogenase enzyme and the boiled medium probably supplies the necessary subtrates. The nitrogenase enzyme has been partially purified by its adsorption and subsequent elution from gels. In crude extracts, the ^{13}N is incorporated into ammonia and amino acids, but the purified enzyme incorporates the ^{13}N into an unidentified compound, which is likely to be an intermediate between nitrogen gas and ammonia. Since these extracts do not utilize $^{15}NO_3$ or $^{15}NO_2$ it is unlikely that the initial activation of nitrogen gas is an oxidative process.

Utilization of Nitrate-Nitrogen. The marine bacterium *Photobacterium fischeri* has been found to require molybdenum and iron when it is dissimilating nitrate-nitrogen. The nitrate reductase activity of the cells increased as the oxygen tension in the culture medium was decreased, indicating that under semi-anaerobic conditions nitrate is an alternative hydrogen acceptor to oxygen. Similar results were obtained with *Pseudomonas fluorescens.*

Cobalt has been found necessary for the growth of a number of micro-organisms when utilizing nitrate nitrogen ; they include *Rhizobium japonicum* and *R. trifolii*, *Azotobacter vinelandii* (OP), *Escherischia coli* (BLA) and various strains of yeast. Chemical methods were developed to reduce cobalt in the culture medium to about 1 mμg/litre. It is imperative to deplete the organisms of the micronutrient by passing them through several cultures of media deficient in cobalt. The growth response in *Rhizobium* occurred between 0.1 and 2 μg cobalt/litre, but for the other micro-organisms it was from 0.01 to 0.1. At equivalent concentrations, vitamin B_{12} was more effective than cobalt. In *Rhizobium* and in *Azotobacter* the nitrate reductase enzyme was markedly reduced when cobalt was deficient, but the micronutrient (labelled with ^{58}Co) did not concentrate in the purified enzyme. The uptake of nitric oxide was also much reduced when cobalt was limiting. Cobalt is also required when *Azotobacter* is fixing nitrogen ; thus in deficient cells the atom per cent excess of ^{15}N was reduced to one-tenth of that in normal cells. Although the micronutrient is also essential for the growth of these organisms on ammonia, the concentration is usually lower than that needed with nitrate.

Nitrification. It has been confirmed that dehydrogenation occurs during the conversion of hydroxylamine to nitrite by cell-free extracts of *Nitrosomonas europeae* in the presence of cytochrome c or dyes (Annual Report for 1960, p. 34). The terminal oxidation systems which transfer the resultant reducing power to oxygen have been investigated spectrophotometrically in anaerobic conditions. Added cytochrome c was reduced when hydroxylamine, DPNH, or TPNH was added : hydroxylamine did not, however, reduce added DPN or TPN. Manometric techniques showed that cytochrome oxidase activity was present.

See also Nos. 23, 24, 25, 26, 37, 38, 47, 48 and 49 in *Publications, 1961,* pp. 53-55.

Plant Constituents.

An investigation of the movement of organic substances in apple and pear seedlings has been started. Experiments on the uptake of ^{14}C-labelled carbon dioxide by a single attached leaf have confirmed that export of labelled sorbitol takes place quickly : in less than twenty-four hours activity appears in the stem and roots, in leaves near the growing point, and in those leaves above the treated leaf which are in vascular connection with it, but not in leaves below it. In contrast, when labelled sucrose or sorbitol is taken up through a petiole from which the leaf blade has been removed, activity appears in leaves below the point of injection as well as in those above. This pattern of distribution after petiole injection is also shown by soluble phenolics such as arbutin and chlorogenic acid, and appears to be the same as that found by Roach for certain water-soluble dyes. Only those substances that have, on a paper chromatogram with water solvent, an R_F value greater than about 0.3 seem to be mobile in apple and pear seedlings after petiole injection. Similar behaviour is observed after uptake through the roots, or by cut shoots or detached leaves. A low R_F value on paper in water solvent indicates strong adsorption of the substance by cellulose under conditions similar to those in the vascular system of the plant, and this offers a simple explanation of the failure of many substances to move within the plant.

An examination of a large number of juice samples from several varieties of high-tannin cider apples has been made in an attempt to correlate measurable chemical properties with subjective assessments of tannin characteristics. No simple correlation seems to be possible. Quite wide variations of the absolute quantities and relative proportions of the individual phenolics are found among different samples of the same variety, but in certain cases clear varietal characteristics stand out, such as the preponderance of chlorogenic acid over flavanols (catechins and leuco-anthocyanins) in Yarlington Mill and Michelin, and the converse predominance of flavanols over chlorogenic acid in Tremlett's Bitter and Ellis Bitter.

See also No. 50 in *Publications, 1961*, pp. 53-55.

Entomology.

Biology of Insect Pests.

The identification of specimens collected during the ecological survey on black currants has continued, in association with a study of the behaviour of species of economic importance. The distribution of species in the litter layer after straw mulching was found to be affected by the humidity level ; the main system is one in which parasitic mites are the main predators and Collembola the chief prey.

The exposure of non-infested black currants at weekly intervals in an infested plantation has shown that in 1959, 1960 and 1961, approximately half the total infestation of axillary buds by the Black Currant Gall mite (*Phytoptus ribis* Nal.) took place during the blossom period. The effects on the plant, and on pollinating insects, of acaricides applied during this period are being determined.

Investigations have been continued with the Willows Section of the time of emergence, periods of greatest activity and the rate of growth and

spread of populations of the Willow Weevil (*Cryptorrhynchus lapathi*), particularly in the Somerset area.

Spray Techniques.

Comparisons have been made, in field trials, of the effectiveness of two applications of 1% and ½% lime sulphur, two wettable sulphur products and Thiodan against the Black Currant Gall mite. There were no significant differences between the reductions in mite infestation caused by sulphur and Thiodan sprays when all were applied by hand lance at high volume rates. Previous experiments, indicating that ½% lime sulphur was as effective as 1% lime sulphur, were confirmed. Field trials also showed the importance of a good wetting agent in the control of the mite. Three applications of 1% lime sulphur together with 0.0125% dinonyl sodium sulphosuccinate reduced mite infestation by 94.1%, whereas three applications of 1% lime sulphur without wetting agent completely failed to control the mite.

In preliminary experiments on the effects of spray materials on the Fruit Tree Red Spider mite (*Metatetranychus ulmi* Koch), commercial preparations of 1, 1, 1-trichloro-2, 2-di(*p*-chlorophenyl) ethanol used at a concentration of 0.231% active material, S-(3, 4-dihydro-4-oxobenzo-1, 2, 3-triazin-3-yl) methyl O,O-dimethyl phosphorothiolothionate at 0.0375%, 2-(1-methylpropyl)-4, 6-dinitrophenyl-$\beta\beta$ dimethyl acrylate at 0.04% and demeton-methyl at 0.0375% were compared with Long Ashton formulations of chlorobenside at 0.02% and phenkapton at 0.0125% on a Worcester Pearmain plot previously sprayed twice with a DDT emulsion. A single large-volume hand lance application of each material three weeks after petal-fall caused the foliage to remain green throughout the remainder of the season while the foliage on the unsprayed trees was severely bronzed by a heavy spider mite attack. Control of the mite was not, however, complete on any of the sprayed trees. A small-scale experiment to determine the effect of these materials on the winter eggs at the beginning of the hatching period showed that the acrylate and the chlorobenside, applied in large volumes, gave significant reductions of hatching mites, whereas the remaining materials had virtually no effect. The indications are therefore that the main effect of these materials in the field is on the mites after hatching and on succeeding generations on the foliage. Further experiments showed that the dilute materials applied to the upper surfaces of the leaves failed to kill the summer eggs on the under surfaces.

In further work on the use of fluorescent tracers for the detection of small droplets it was confirmed that with practically all tracers droplets not less than 50 μ in diameter can be seen by eye and those not less than 15 μ by microscope. The best concentration for the field use of oil colour 7 G was found to be 0.01–0.02 per cent.

The flying spot particle resolver has been used to calibrate laboratory spraying apparatus including compressed air-spray guns and a spinning disc. The instrument is now being used for the assessment of the droplet spectra produced by crop spraying equipment. Various plastic materials have been tested as droplet-collecting surfaces and some have shown promising improvements over the glazed photographic paper previously used.

Field experiments on the control of Frogeye Disease (*Cercospora nicotianae*) of cigar-wrapping tobacco were continued in North Borneo. A com-

parison was made between the pneumatic hydraulic knapsack applying 75 gallons per acre, normally used, and a knapsack mist-blower applying 24 gallons per acre, both machines using a copper oxychloride spray at 0.1 per cent copper. The crop was sprayed ten times at intervals of five days and records were made of the levels of spray deposit after each application and of the incidence of disease. The mist-blower gave a satisfactory control of disease with a saving of 60 per cent in material and 75 per cent in labour costs.

Kenya, Tanganyika, Zanzibar, Uganda and the Sudan were visited by H. G. H. Kearns in February and March, with a second visit to the Sudan in October. Advice was given on the potential uses of low-volume spraying on coffee, limes, cereals and cotton. Preliminary investigations were made on the distribution and levels of copper sprays on limes and coffee.

The spraying methods used on cotton in the Sudan were critically assayed using fluorescent tracers and chemical micro-assays of spray deposits. It was shown that the current method of spraying failed to give any spray deposit on the underside of the leaves, which is the normal habitat of jassids, white flies and thrips. Experiments are in progress to improve the spray technique.

Spray Machinery.

An experimental mist-blower is under construction for biological and physical assessment of small-volume spray applications on black currants and top fruit. Stainless steel pneumatic sprayers with a special design of lance for the application of concentrated insecticides have been supplied to the Tsetse Control Organisation in Bechuanaland. A new type of drop-arm nozzle assembly has been designed for attachment to row-crop sprayers for the spraying of cotton in the Sudan Gezira ; it incorporates a flexible tube, filter and adjustable angle ceramic nozzle. All the fittings are brass pressings and all the joints are of metal to metal taper design which obviates the use of washers. A spray nozzle assembly was designed for fitting to hand lances and tractor mist-blowers for the application of concentrated copper fungicides to coffee in South India and East Africa.

Plant Pathology.

In a trial on Cox's Orange Pippin apples, against both scab and mildew, glyodin was significantly inferior to captan or dodine in scab control. The incidence of secondary mildew was not affected by these three fungicides, but was slightly less after two dinocap sprays than after two sulphur sprays. In another trial, 2, 4-dinitro-6-*sec*-butyl phenyl dimethacrylate equalled dinocap in controlling apple mildew without impairing skin finish ; four applications also gave a good control of red spider.

In apple canker trials, no significant overall reduction of leaf-scar infection was achieved by three sprays of Bordeaux mixture during autumn 1960 and spring 1961, but there were indications that infection had occurred before the first application in mid-October. In experiments to accelerate leaf-fall preparatory to protectant spraying of leaf scars, di-pyridyl and di-nitrocresol as the sodium salt were slightly more effective than Bordeaux mixture, but the defoliation occurred two weeks after spraying. No correlation was found between the nitrogen or magnesium content of shoots and the incidence of canker.

Inoculation of Cox leaf-scars in autumn 1960 with spores and mycelium of *Gloesporium perennans* showed that susceptibility to infection increased as natural leaf-fall became imminent. In addition to buds killed by leaf-scar infections, up to 25% of infected scars were cankered by the following summer (1961). Wood infections on trees given different pruning treatments (summer and winter, and winter only) for several years indicated that lateral wounds and pruning cuts were generally more susceptible to infection on trees pruned only in winter.

Preliminary results of fruit infections with spores of *G. perennans* showed that Worcester Pearmain fruit from arable plots began to rot more quickly than fruit from clover plots ; fruits from perennial rye plots rotted more slowly than all other fruit. While this differed from the results obtained in 1960, the differences were not very great ; all fruit rotted more slowly than in 1960. Except on the timothy and arable plots, the addition of nitrogen to the trees hastened the rotting of fruit in store. Cox's Orange Pippin fruit similarly inoculated showed much the same result, except that fruit from perennial rye plots rotted more quickly than that from timothy and " tumble-down " plots : here the additional nitrogen was beneficial on all except the arable and " tumble-down " plots.

Trials of spray materials for the control of *G. perennans* on a commercial scale were continued in co-operation with Kirdford Growers Ltd., Ditton Laboratory and British Drug Houses Ltd. Trapping of spores from trees selected at random in treated orchards was continued, the collections being sent to Long Ashton for counting, and viability tests. Biological tests on the effects of the fungicides in use in the field have been continued at Long Ashton, on small trees in pots.

The powdery mildew on strawberry has been shown to be a specialized race, confined to this host. No strawberry varieties commercially grown in England have immune foliage, but those with robust, heavily-cuticularized leaves (e.g. Huxley, Cambridge Favourite) are the most resistant. Generally, spore dispersal is at a maximum in the afternoons but is drastically reduced by rain ; most spores are deposited within a few feet of the host plant. No method of perennation of the fungus has been found except as mycelium on living, overwintering leaves : preliminary experiments suggest that such leaves might be killed by spraying in November with the desiccant diquat at 1 lb./100 gal./acre, without damage to crowns and buds (p. 153). At Luddington three applications of a dinocap+wetter spray reduced the proportion of mildewed fruit to 17%, compared with 72% on the unsprayed plots : lime sulphur was equally effective. Decreasing the number of applications resulted in progressively poorer control.

Field trials on black currants at Efford against *Pseudopeziza ribis* (leaf spot) showed that pre-harvest were generally better than post-harvest treatments in reducing leaf spot in the current season. Experiments with overwintered leaves suggested that late sprays were superior to early ones in reducing inoculum (ascospores) in the following spring. The best treatment of all was four sprays (two pre-harvest and two post-harvest) of zineb, which was generally better than captan under comparable conditions. Crop weights from all treated plots were greater than from untreated plots, giving up to 16% more fruit on Mendip Cross and 35% more on Baldwin (p. 144).

Work with oils on banana leaves suggested that at rates of field applica-

tion, respiration of leaves was upset, either because of internal phytotoxic damage, or of blocking of gaseous exchange at leaf surface. Other physiological processes also showed changes after treatment with oil (p.163).

In further biochemical studies of the process of infection of apple fruit by the brown rot fungus, it was found that the induction of the enzyme polygalacturonase by the fungus could be inhibited by the purine antimetabolite 8-azoadenine. Conventional fungicides such as captan, dodine and sulphur had no such inhibitory effect.

See also Nos. 12, 18, 33, 34, 35 and 39 in *Publications, 1961*, pp. 53-55.

Cider and Fruit Juices.

Organic Constituents.

In collaboration with Professor Kenner and co-workers (University of Liverpool), a sample of 4-methylproline isolated from perry was shown to have the structure *trans*-4-methyl-L-proline (9). The corresponding 4-hydroxy derivative, which is a prominent amino acid in some ciders and perries, was shown by proton magnetic resonance studies to be 4-hydroxymethylproline, rather than 4-hydroxy-4-methylproline (10).

Work on the gas-liquid chromatography of volatiles of apple and pear juices and perries has continued. The assembly and use of a flame ionisation detector unit has revealed the presence of a wider range of volatile components. Series of alcohols, esters, aldehydes and other substances have been tentatively identified by comparison of relative retention times with standard substances on at least two different static phases. The volatiles present in clear and cloudy apple juices do not appear to differ qualitatively, but the clarified juice contains more methyl, ethyl, and N-butyl alcohols, the same quantity of higher alcohols, though slightly less butyl esters than does the cloudy juice. Perry pear juices and perries made from them were again similar qualitatively, but the proportion of higher alcohols was greater in the fermented products.

Metallic Complexes.

Complex formation between ferric iron and malic, tartaric and citric acids has been studied in model systems by means of potentiometric and oxidation-reduction potential measurements. The accuracy of the experimental technique was checked and confirmed by preliminary work on the known ferric acetate and ethylene-diamine tetra-acetate systems. The results, while not yet fully evaluated, indicate that all three acids combine most effectively with ferric iron. For example, malic acid, at a concentration and pH found in a typical apple juice, reduced the concentration of free ferric iron to about a millionth part of the total ferric iron. Further confirmatory work is in progress using spectrophotometric and ion-exchange methods.

Unfermented Juices.

Work on unfermented fruit juices has in the past year been increasingly linked with the activities of the Horticultural Marketing Council through its Fruit Processing Committee. This is engaged in examining outlets for out-graded and surplus fruit produced in the U.K. In the winter of 1960/61 the Section prepared for the Council a bulk of apple juice for inclusion in a consumer acceptance test commissioned later in 1961.

The increased interest in fruit juices now being shown by the food and beverage industries and by fruit growers has extended the advisory work of the Section. This has included investigations of juice production methods and tests of plant and equipment. It is probable that an expansion of juice production will call for an increasing use of concentration as a means of holding stocks, equalizing fruit supplies, and standardizing juice composition.

Topics being currently studied, and on which further information is desirable, are the methods of production of juices and concentrate, and the effect of storage conditions upon quality. Development work on blended juices is also proceeding.

Sulphur Dioxide in Cider-making.

The equilibria between free and bound SO_2 in ciders have been further investigated and the dissociation constants of some of the known bisulphite compounds present have been determined (41). During the work it became apparent that very accurate determinations of both free and total SO_2 were necessary since any error is interpreted as bound SO_2. Suitable methods for these determinations have been developed. Improvements have also been made in the iodimetric titration of acetaldehyde-bisulphite (8). Using these methods the SO_2-binding curves (i.e. the extent to which added increments of SO_2 become combined with other cider constituents) have been determined for a number of ciders. With normal ciders it is usually possible to achieve 30-50 p.p.m. free SO_2 without exceeding the permissible 200 p.p.m. total SO_2. There are, however, indications that ciders produced from concentrated juice may have an abnormally high SO_2-binding power, which remains in the fermented cider.

For some of the ciders examined, their content of pyruvic acid, α-keto-glutaric acid and xylosone has also been determined. The sum of the calculated SO_2-binding powers of these constituents and of acetaldehyde and glucose was insufficient to account for the observed binding power of the ciders. Phenolic components present appeared to have little effect on SO_2-binding power. The unidentified SO_2-binding power of ciders appears to be mainly due to other non-acidic components. Thus in the juice from 50%-rotten apples, only one-third of the SO_2-binding power was absorbed on an anion exchange column (I.R.A. 400-acetate), the remainder being due to neutral substances.

Microbiology.

Yeasts. As part of a long term study of the yeasts present in cider factories, an examination has been made of the yeast flora of apples gathered aseptically from trees grown in Devon, Hereford and Somerset. The isolates from all the samples were very similar, consisting of species of *Candida*, *Rhodotorula* and *Hansenula*. Only one species of *Saccharomyces* was isolated; *Kloeckera* spp. were confined to fruit harvested from the ground. Other yeasts, isolated from freshly pressed juices collected in cider factories receiving fruit from the same orchards, are now being identified.

The methods available for estimating changes in yeast populations have been found unsatisfactory. Hence a detailed examination was made, in conjunction with the Statistics Section, of the errors inherent in the drop counting technique. In the method evolved, some 2000 colonies are counted per sample,

giving an error of $\pm 8\%$ at 95% confidence limits. This has been used to investigate the effects of free SO_2 on *Saccharomyces cerevisiae* suspended in a simple buffer. A significant decrease in viability occurring in the non-sulphited buffer at pH 3.0, but not at 4.0, could be overcome by the addition of bovine serum albumen, but not of peptone. There was no significant difference in the LD_{50} values of the mass culture and of cultures prepared from single cells derived from the untreated and sulphite-trained mass culture.

The viability of pure cultures of cider yeasts in sterile apple concentrates has been tested during storage for 3 months at three different temperatures. The effects of pH, sp. gr. and state of oxidation have also been examined. The yeasts could be classed as osmophilic, osmotolerant or osmophobic, according to their behaviour towards concentrates. *Debaryomyces kloeckeri*, belonging to the second group, has not been found previously in this habitat. The degree of survival of the three groups was reduced in concentrates that were of low pH or excessively oxidized. An osmophilic yeast isolated in a cider factory was much more vigorous than any culture yeast, fermenting a synthetic sugar medium, sp. gr. 1300, over a pH range 2.6 to 7.0.

Bacteria. In view of the distinction made between *Acetomonas* and *Pseudomonas* (Annual Report for 1960, p. 42) it was considered necessary to examine claims made in the literature that the latter is able to oxidize ethanol to acetic acid. A strain of *Pseudomonas fluorescens*, known to utilize ethanol, was found to produce acetic acid when grown in the presence of this substrate. There were, however, notable differences which distinguished it from *Acetomonas* growing on the same substrate. Whereas *Acetomonas* requires organic nitrogen for ethanol oxidation, the *Pseudomonas* was found to need inorganic nitrogen ; the *Pseudomonas* ceased acetic acid production in an unbuffered medium when the pH had fallen to 5.0 whilst *Acetomonas* can continue this activity at pH 3.6 and below ; *Acetomonas* is unable to continue the oxidation beyond acetic acid whereas *Pseudomonas* can oxidize this further to carbon dioxide and water. Thus, although both genera oxidize ethanol, the distinction previously made between *Acetomonas* and *Pseudomonas* on other grounds is strengthened by their different behaviour during ethanol oxidation.

A commercial cider-vinegar generator, of the trickling type in which the naturally occurring flora is allowed to carry out the acetification, was investigated over a period of 3 months in order to follow changes in flora. Altogether 121 isolates were identified during eight samplings of the inflowing and outflowing liquids and of the supporting birchwood twigs. The first liquid samples, taken soon after the generator had started, contained *Acetobacter aceti*, *A. rancens*, *A. ascendens* and *A. lovaniense*. Although present on the twigs, *A. xylinum* did not occur in the liquid samples at this stage. It was found, together with *A. mesoxydans* and *A. estunense*, in the next set of liquid samples, and multiplied rapidly, causing the birch twigs to become blocked with masses of cellulose which impeded the flow of liquid and air and gradually reduced the efficiency of acetification in successive batches of cider. It was the only species besides *A. rancens* to survive long enough to appear in the final vinegar sample. Over the whole survey, the proportion of species isolated was as follows :—*A. xylinum*, 49% ; *A. rancens*, 33% ; *A. lovaniense*, 10% ; *A. mesoxydans*, 3% ; *A. ascendens*, 2.5% ; *A. aceti*, 1.5% and *A. estunense*, 1%.

By invitation, an investigation of the acetic acid bacteria in the National

Collection of Industrial Bacteria was undertaken jointly with Dr. J. L. Shimwell of British Vinegars Ltd. These organisms, which totalled some 97 strains, were re-identified according to the criteria of Frateur and divided into the two genera *Acetobacter* Leifson and *Acetomonas* Leifson, Shimwell and Carr. Although some names had of necessity to be changed in order to conform to modern nomenclature, there were some strains that had been wrongly identified, including some which were not acetic acid bacteria at all.

Metabolism of Malate and Citrate by Lactic Acid Bacteria.

Six lactic acid bacteria isolated from ciders have been studied in detail with regard to their malate and citrate metabolism. Two (nos. 30 and 73) were typical cider heterofermentative rods of the *Lactobacillus brevis/pastorianus* group, Isolate 73 being noteworthy in that growing cells produced a higher proportion of succinate to lactate from malate dissimilation than most other heterofermentative lactobacilli, the proportion increasing as the pH of the medium was increased. Two (nos. 5 and 25) were heterofermentative lactic cocci or *Leuconostoc* spp. and two (nos. 24 and 28) were homofermentative rods of which no. 24 was a lactobacillus noteworthy for its catalase positive reaction, while no. 28 corresponded closely to *Lactobacillus plantarum* (*arabinosus*) 17–5. The acid metabolism of washed cells of each isolate was measured manometrically and by quantitative determination of the non-gaseous end-products. A balance-sheet was drawn up for each isolate and substrate over the active pH range.

Isolate 28 alone showed the presence of an adaptive malic enzyme; its Q_{CO_2} value (360 μl. per mg. dry wt. cells per hour) and optimum pH (4.5–5.0) were similar to those of *L. plantarum* 17–5, and the organisms appear identical. The five other isolates had constitutive enzyme systems for the metabolism of malate. Isolate 24 also had a pH optimum of 4.5–5.0 but was more active than Isolate 28 at the lower end of its pH range (3.5–6.0). The heterofermentative cocci nos. 5 and 25 showed active metabolism in the pH ranges 3.5–6.0 and 3.0–5.5 respectively, while their optimum pHs were 4.0–4.5 and 3.5–4.0. The heterofermentative rods nos. 73 and 30 showed pH optima of 4.5 and 4.0–4.5 respectively, but when grown with glucose and citrate no. 73 showed a pH optimum of 5.0.

The main end-product with five isolates was lactate, which appeared in equimolecular amounts relative to the malate metabolised and CO_2 evolved. One of the heterofermentative rods, Isolate 73, yielded appreciable amounts of succinate, particularly at the higher pH levels; at pH 5.5 more succinate (as determined by succinic dehydrogenase) than lactate was formed and the CO_2 evolved was correspondingly lower.

Only the isolate with an adaptive malic enzyme (no. 28) was inactive to citrate. The enzyme in each of the other five isolates attacking citrate was adaptive. Isolate 24 yielded acetoin as the main product in the pH range 3.5–6.0 with little variation in the Q_{CO_2} value (200); phosphate and glucose accelerated citrate metabolism. Isolates 5 and 25 actively metabolised citrate in the pH range 3.5-6.0 with an optimum at pH 4.0 (Q_{CO_2} 250 and 300 respectively); at the lower pH levels acetoin was the main product but at higher pH values the proportion of lactic acid formed increased until towards pH 6.0 considerably more lactic acid than acetoin was formed; addition of glucose

completely suppressed acetoin formation. Isolates 30 and 73 metabolised citrate actively with optimum pH values of 6.5 and 5.0 respectively ; lactic acid was the main product of metabolism. The five isolates showed the presence of an adaptive citritase yielding initially oxalacetate and acetate ; the former was then decarboxylated to pyruvate. Although the washed cells were not very permeable to pyruvate, added pyruvate yielded end-products similar to those from citrate.

None of the isolates examined showed any significant oxidative capacity towards malate, citrate or the products of their anaerobic metabolism.

Cider-making Operations and Equipment.

In the exploration of methods for reducing manual labour in cider-making, fruit harvesting and juice extraction have both been studied. Trials of mechanical harvesting with a spiked drum showed that, contrary to expectations, the spiked fruit stored well, showed no significant loss of sugar during washing and no increase in the iron content of the juice. The machine required only one-half the labour used to harvest the same weight of fruit by hand, and picked up an excessive amount of debris only under trees that had lost their leaves.

Trials of machines for continuous extraction of apple juice from milled pulp were made using a vertical centrifuge and a roller-type press. The centrifuge processed pulp at the rate of 8 tons per hour, but yielded only 55% of the weight of the pulp as juice, which had a high suspended solids content. The roller press, with a much smaller power consumption, processed 1½ tons per hour, with a similar juice yield but with lower suspended solids. Hydraulic pressing of residues from both machines gave a combined yield that compared very favourably with a conventional double hydraulic pressing. A demonstration of the machines was held for the benefit of juice and cider makers and the results are discussed on p. 176.

See also Nos. 1, 2, 8, 9, 10, 15, 16, 17, 40 and 41 in *Publications, 1961*, pp. 53-55.

Willows.

Variety Collection.

Cuttings of four selected varieties of basket willows were received from East Germany, bringing the total number of varieties in the collection to 207. An area laid out to incorporate tree willows was planted with eight different clones.

Experimental Work.

In its first year the spacing and method of planting trial with Black Maul, established in 1960, showed no differences in the number or length of shoots due to the five spacings employed, but cuttings planted level with the ground produced significantly fewer shoots than those planted with a portion of the cutting above ground. In 1961, significant differences due both to spacings and planting methods were found ; wide spacings produced more and longer shoots per stool ; level planting gave fewer but longer shoots.

Assessments were made in July and November of the residual effect of dalapon applied in 1960 on grasses in willow beds. The effect on the ground flora has persisted ; counts made in July showed that the area occupied by

grasses was 7% and 5% in plots which received 5 and 10 lb. active material/acre respectively, compared with 54% in the control plots. Weeding has not been necessary in the sprayed plots. Neither rate damaged this season's willows or had a significant effect on the number or length of shoots. Applications at the rate of 5 lb./acre in March, April or May, 1961, gave a good control of grasses and rushes : that in March gave a significant increase in willow shoot length and also a significant increase in the area occupied by silverweed, fleabane and dandelion (p. 191).

A test of residual herbicides at Long Ashton showed that simazine, neburon and diuron at 4, 4, and 2 lb. respectively of active material/100 gall./acre, controlled annual weeds in a newly planted willow bed without damage to the willows. Applications in May of 1, 2, and 3 lb./100 gallons/acre of diquat killed willow shoots of mean length 10.5″ without permanent injury to the stool : three weeks later new buds sprouted from the stool and grew normally. These treatments had little permanent effect on grasses and weeds, but showed that diquat could be used in place of tar oil to kill off willow foliage for a limited period, to avoid damage by late-spring frosts.

Studies on the etiology of willow rust, *Melampsora amygdalinae*, were made in collaboration with the N.A.A.S. for a third year on five beds varying in age from two to eight years. Humid weather in June encouraged the disease and in October the mean number of cankers in a heavily infected bed was 1.8 per rod compared with 1.3 and 0.02 in 1960 and 1959 respectively. It is doubtful whether such a crop pays for harvesting.

Two willow cutting machines were tested in Somerset in collaboration with the Workshops Section. Cutting was greatly aided by the absence of grass and weed in plots sprayed with dalapon. No significant difference was found in the number and length of shoots produced in the first year by stools cut mechanically or by hand ; the long-term effect is being studied.

Advisory Work.

There were 203 requests for information during the year ; 50 visits were made as below :

	South West	Home Counties	East Anglia	Midlands	North Wales	Scotland	Foreign
Enquiries	45	31	25	14	10	10	58
Visits	33	3	10	—	—	2	2

Requests for planting material included four from educational centres and two from European research stations wishing to include the bat willow (*Salix alba* var. *caerulea*) in their collection of fast-growing trees for the production of pulpwood and chip veneer. Information on this topic was obtained during visits to the Italian Institute for Poplar Research, Casale Montferrato, and the Congress of the International Union of Forest Research Organisations in Vienna, in September. In most Continental countries work is at present limited to the collection and selection of naturally occurring clones, predominantly of *S. alba* or its hybrids with *S. fragilis*. At Long Ashton, sets of six promising tree willows are being raised for a trial plantation.

Since 1957 the section has been associated with a scheme to establish basket willow growing in the Western Highlands of Scotland. Four varieties

of *S. viminalis* were sent for trial and sufficient information has now been obtained to advise farmers on methods, costs and local markets.

This season's crop of Somerset willows was moderate and of poor quality. Many beds were flooded for several months in winter and spring, preventing harvesting; crops in about 10% of the area were run-on for a second year. One-year-old crops totalled 927 acres, but their quality was spoilt by frost on the 26th and 27th May, and later by stem cankers caused by willow rust. To maintain the standard of processed bundles a high proportion of the crop will have to be rejected, and growers estimate that the marketable crop will be only 60% of that of last year. They anticipate some difficulty in meeting the increased demand for willows and expect that the price per processed bundle will rise to 30/- for " white " and 28/- for buff.

Domestic Food Preservation.

Bacteriological analyses of deep-frozen vegetables continue. It has been found that organisms are usually present in numbers too low to be reliably counted by normal techniques (p. 181) and it is therefore planned to follow the changes that take place during freezing and thawing by using packs inoculated with representative species of these organisms, which are now being isolated and identified. The effect of the thawing rate on the flavour and texture of deep-frozen foods is also being investigated.

Quality assessment of colour, texture and flavour of preserved vegetables has been made. Thirty varieties were tested and a further nineteen varieties preserved for testing during the coming year.

The testing of preserved fruit has included nineteen varieties of apples, fifteen of blueberries, and four of strawberries. During the autumn fifteen varieties of cooking apples, all from the National Fruit Trials, Faversham, have been tested stewed and baked and also preserved for subsequent testing. A late frost adversely affected all the blueberries in the N.A.A.S. trials at Wareham and unfortunately no supply was available for testing this season.

The tasting of fruit treated with spray chemicals has continued. For the Plant Pathology section, strawberries sprayed with thiram alone or with thiram plus Karathane or lime sulphur have been tasted fresh, canned and frozen. For the Entomology Section canned black currants, with various lime sulphur treatments, have been similarly tested (see Statistics Section). Four samples of gooseberries grown on soil treated with different herbicides were canned and subsequently tested.

The use of some new domestic equipment for fruit syrup making has been investigated, and the effect of storage temperature on the consistency of tomato juice is being studied. The correct covering of vinegar preserves is often a problem for the housewife and a further experiment on such covers is reported on p. 184.

Besides two general courses in Fruit and Vegetable Preservation, a specialist course in Domestic Deep Freezing was held for lecturers in Domestic Science Training Colleges. The interest in this subject is increasing and it is hoped to arrange similar instruction next year.

See also No. 19 in *Publications, 1961*, pp. 53-55.

Statistics.

Experimental Design and Analysis.

The section has given the usual large amount of advice and assistance to Station staff, and has also been consulted by workers in the University and the N.A.A.S.; lectures have again been given in the University.

Planning for the replanting of Long Ashton plots with long-term experimental material has continued, and several single-season trials have been designed for fungicides, herbicides, growth substances and nursery material. Work has also been planned for sites outside Long Ashton, especially with willows; the results analysed from these sites have included extensive ecological surveys.

Among the analyses of laboratory results, microbiological experiments have been prominent; various technical aspects of the conduct of the experiments have been examined as well as differences due to treatments. A considerable amount of mycological work, including spore germination tests, has also been dealt with.

Designs having properties similar to those of graeco-latin squares, though based initially on Youden squares rather than on latin squares (Annual Report for 1959, p. 41), have been further examined and a better method of construction has been found; a report is in preparation.

Biometric Studies.

A report has appeared (19) on tasting trials of strawberries from field plots sprayed with fungicides, and further results from field trials with strawberries are now available (p. 197). Results for black currants in 1955–60 indicated that malathion at 0.075% did not taint fruit; BHC caused taint only at a concentration of 0.0375%, not at 0.014% or less; 1% lime sulphur caused quite detectable taint when sprayed more than three times in the season and occasionally when sprayed only three times.

The first results on the relation of cane growth to crop weight in raspberries grown in sand culture indicated that cane length might be a satisfactory calibrating variate but that there was no advantage in taking girth or volume of cane into account. In cases where some canes were lost from a pot, for reasons not connected with experimental treatments, it was further apparent that simple calibration by the number of canes lost was almost as effective as using previous growth records of the lost canes. A further season's results will be available from this trial.

As reported last year, the apple variety Cox's Orange Pippin was much less uniform in its growth in the nutrition trial on Plot 18 than the variety Worcester Pearmain in adjacent rows. This pattern has been repeated in the portion of the plot which has received foliar sprays as part of its nutrition programme (Plot 18b). There is also evidence of similar differences among the three varieties of pear on Plot 7. Before differential treatments begin, more evidence will be gathered as to the length of time needed for these varieties to settle down to uniform growth; the present indication is that Williams' needs less time than Comice, with Conference the slowest in achieving uniformity.

See also No. 19 in *Publications, 1961*, pp. 53-55.

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TOR CROSS; A NEW EARLY BLACK CURRANT VARIETY

By D. WILSON.

The black currant variety Tor Cross originated in a family of seedlings raised by Spinks in 1924 from a cross between Baldwin and " an unknown variety resembling Boskoop Giant." In 1930 it was selected, together with four other seedlings from the same family, as meriting further trial. Thereafter, it competed with the seedling of similar season which was eventually named Mendip Cross, and at that time the latter was preferred. However, following post-war changes in the black currant industry, Mendip Cross declined somewhat in popularity and the possible value of Tor Cross was reconsidered. It was included in a new variety trial started in 1954 and from this trial it became apparent that Tor Cross would be a useful addition to the present range of black currant varieties. Most of the following notes are drawn from this recent trial.

Description.

Bush characters. From Plate I it can be seen that, at the end of the first cropping year, Tor Cross (Fig. 1) was similar in vigour to Mendip Cross (Fig. 2) but slightly more spreading in habit, giving a wide flat-topped bush. The photograph also demonstrates the ample supply of strong basal one-year-old shoots in Tor Cross which simplifies pruning and refurnishes the bush with plenty of cropping wood. The ripened one-year shoots are grey-brown in colour and the pink-red buds are large, pointed and smooth in outline. In July the young shoots are tinged with deep red and have moderate to dense pubescence. The rather long, slender petioles are mainly green but have a red tinge at the base. The large, broad leaves have a deep, narrow, acute basal sinus and the broad terminal and lateral lobes are of medium length and acute at the apex.

Flower characters. Tor Cross flowers with the mid-to-late season varieties. The racemes, often in pairs, usually carry from 7–11 flowers with an average of just over 9. The anthers are more or less level with the stigmas and this fact, together with the high degree of self-fertility, should ensure adequate fruit-set even in the absence of cross pollination.

Fruit characters. In the variety trial, Tor Cross was picked on the same dates as Mendip Cross in most years, but later evidence suggests that, at least on some sites, it matures 2–3 days after Mendip Cross. From Table I it can be seen that Tor Cross consistently outyielded Boskoop Giant and also, except for the first cropping year, Mendip Cross. At harvest time there was an average of 9 medium to large berries per strig and ripening was even along the strig and throughout the bush. There was less pre-harvest splitting or dropping of basal berries than in Mendip Cross and the fruit suffered less damage in picking and transit. Ease of picking was classed as " average." The ascorbic acid content of the fruit (182 mg.% in 1960; 176 mg.% in 1961) was better than in Mendip Cross (152 mg.% in 1960; 169 mg.% in 1961) and satisfactory for an early variety.

Fig. 1. Unpruned bush of Tor Cross after first cropping year.

Fig. 2. Unpruned bush of Mendip Cross after first cropping year.

TABLE I.

YIELD PER BUSH OF TOR CROSS, BOSKOOP GIANT AND MENDIP CROSS OVER A FOUR-YEAR PERIOD.

	*Yield in lb. per bush of		
	Tor Cross	Boskoop Giant	Mendip Cross
1956	2·10	1·40	2·43
1957	6·43	5·05	4·50
1958	3·36	0·92	1·95
1959	3·42	2·24	2·95
Mean	3·84	2·40	2·96

* Calculated from 40 bushes arranged in 4 randomized blocks of 10 bushes each.

Discussion.

From the above data it is obvious that Tor Cross is a promising new variety which could well supplement or replace plantings of Boskoop Giant and Mendip Cross. However, as pointed out, these data are entirely drawn from Long Ashton trials and nothing is yet known about its performance elsewhere. Obviously, further trials would have been desirable, but the urgent and persistent demand for a new early black currant variety, balanced against the time necessary for extensive trials in different parts of the country, seemed to justify immediate distribution. In view of the limited trials, it is suggested that, until Tor Cross has proved satisfactory in any given district, only relatively small quantities should be planted.

Summary.

In trials at Long Ashton, the new early black currant variety, Tor Cross, has consistently outyielded Mendip Cross and Boskoop Giant. The fruit is less prone to pre-harvest splitting and dropping than other early varieties and also suffers less damage in transit. Relatively small-scale plantings are advised until more is known of its performance in other areas.

Acknowledgments.

The production of a new variety involves the assistance of too many people for individual acknowledgment. However, special acknowledgments must be made to Mr. G. T. Spinks, the originator of Tor Cross, and to Mr. A. I. Campbell, Mr. E. Catlow, Mr. G. E. Clothier, Mr. J. S. Coles and Mr. E. W. Hobbis, who have all been closely concerned with its subsequent development.

INDUCED PARTHENOCARPY IN BLACK CURRANTS.

By D. WILSON.

Introduction.

The induction of parthenocarpy and the prevention of premature fruit drop have been accomplished in many crop plants and, in some, the methods used have become part of normal commercial practice. The black currant is a notable omission from the comprehensive list of species (1) in which the induction of parthenocarpy has been investigated, especially since spring frost damage to flowers and " running-off " are major problems in black currant production.

The following experiments were designed to investigate the possible induction of parthenocarpy in black currants by the use of growth substances which had been successful with other crops. While the main purpose was to investigate parthenocarpy *per se*, the possibility was also considered that some of the substances tested might be useful in preventing the premature fruit-drop of pollinated berries that occurs in " running-off."

Experimental.

Two-year-old potted bushes of the variety Wellington XXX were brought into a greenhouse early in March ; they produced flowers towards the end of the month. Three or four of the lower flowers on several racemes on selected shoots were emasculated (by removing the upper part of the calyx carrying the stamens and petals) and effeminated (by cutting off the style at the junction with the ovary) just before the flowers would otherwise have opened. The calyx cup was then filled with lanolin carrying one of the following substances at concentrations of 0·1, 0·5, 1·0 or 5·0 per cent :

(1) 2–naphthoxyacetic acid (2–NOA).
(2) 3–indoleacetic acid (IAA).
(3) 3–indolylbutyric acid (IBA).
(4) 1–naphthaleneacetic acid (NAA).
(5) gibberellic acid (GA).

As a control, a comparable number of flowers was treated with plain lanolin.

Records of fruit-set were taken at intervals and the berries were measured and examined after harvesting.

Results.

Table I shows the fruit set at monthly intervals after treatment and the number of berries eventually harvested. It can be seen that treatment with 2–NOA was not successful in inducing parthenocarpy. Two of the 2–NOA applications and all the IAA and IAB treatments, however, delayed fruit drop as compared with the control flowers treated only with lanolin. One mature fruit was produced in each of the 0·1% IAA and the 0·5% IBA treatments, but otherwise the berries did not swell before abscission. The 1% and 5% NAA treatments caused severe leaf damage and, although the former delayed abscission, no parthenocarpic fruits were produced in either treatment. However, the lower concentrations of NAA, while causing only slight leaf damage, did produce parthenocarpic fruits—the 0·1% concentration being the

more effective. All the GA treatments produced parthenocarpic berries, the 5% concentration being the least effective. The treatments had no obvious deleterious side effects on the bushes.

TABLE I.

NUMBER OF FRUITS SET AFTER TREATMENT OF UNPOLLINATED FLOWERS OF WELLINGTON XXX.

Treatment	Concentration	Flowers treated	Fruit set after 4 weeks	Fruit set after 8 weeks	Fruit harvested
Plain lanolin	—	23	0	0	0
2-NOA	0·1%	21	5	0	0
	0·5%	25	0	0	0
	1·0%	28	2	0	0
	5·0%	22	0	0	0
IAA	0·1%	28	12	1	1
	0·5%	29	4	0	0
	1·0%	26	1	0	0
	5·0%	30	0	0	0
IBA	0·1%	27	22	0	0
	0·5%	27	14	1	1
	1·0%	22	20	0	0
	5·0%	26	7	0	0
NAA	0·1%	27	20	17	17
	0·5%	25	16	4	4
	1·0%	32	10	0	0
	5·0%	26	0	0	0
GA	0·1%	25	22	19	18
	0·5%	20	20	19	18
	1·0%	22	21	19	19
	5·0%	23	18	8	8

The fruit produced from all treatments was similar, but that from the NAA treatments ripened some seven to ten days earlier than that from other treatments. In general the fruits were of medium size (5–7 mm.), quite juicy and with a hardened disc where the lanolin had been applied. In some fruits an occasional empty seed coat had developed to full size and in others the small undeveloped white ovules were still present.

Discussion.

The above experiments have shown that it is possible to induce parthenocarpy in black currant. 2–NOA is of no apparent value, and although parthenocarpic berries were obtained with IAA and IBA, these substances are not as efficient as gibberellic acid or low concentrations of NAA. The development of hardened seed coats is similar to that reported in pumpkin and watermelon (2).

The method of application used in these experiments is such that it cannot be considered on a field scale. However, it may be of use to plant breeders to assist in the setting of berries after hybridization between distantly related species or in partially sterile interspecific hybrids.

There is a possibility that spray techniques with these or other growth substances may be developed, which will help to combat spring frost damage and " running-off." In a pilot experiment to investigate the use of growth substances for reducing premature fruit drop in black currant, Teaotia (3) found that the application of NAA at 10 parts per million just prior to the opening of the first flowers gave a significant reduction of drop. However, a subsequent field trial with NAA at the same concentration, applied either at the flower-bud stage or just prior to the early drop, increased rather than decreased fruit drop (4). Further trials with a wider range of concentrations and times of application of NAA seem desirable. Gibberellic acid sprays are also worth investigation, but these may have undesirable side effects on vegetative growth, particularly as Modlibowska has shown the black currant to be " susceptible " to gibberellic acid in at least one of its growth phases (5).

Summary.

Attempts were made to induce the production of parthenocarpic berries by treating emasculated and effeminated blackcurrant flowers with 2–naphthoxy-acetic acid, 3–indoleacetic acid, 3–indolylbutyric acid, 1–naphthaleneacetic acid and gibberellic acid. These substances were applied in lanolin paste at concentrations of 0·1, 0·5, 1·0 or 5·0 per cent.

The only entirely successful treatments were those made with gibberellic acid at all concentrations and with 1–naphthaleneacetic acid at the two lower concentrations, which produced parthenocarpic berries on a high proportion of treated flowers.

Acknowledgment.

I wish to thank Dr. L. C. Luckwill for his advice and interest in this work.

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THE EFFECT OF GIBBERELLIC ACID ON THE CROPPING OF PEARS FOLLOWING FROST DAMAGE

By L. C. LUCKWILL

Introduction.

In a previous publication (2), experiments were described which showed the ability of gibberellic acid (GA) to induce parthenocarpy in pears when applied as a 50 p.p.m. spray to blossoms in which pollination had been prevented by excision of the styles. These experiments and those of Modlibowska (3) at East Malling suggested that it might be possible to use this growth regulator to improve the cropping of pears in years when the styles and ovules of the flowers had been killed by frost.

An opportunity to test this hypothesis came in 1961 when, as a result of an air frost on the night of 19–20 March, extensive damage was caused to the blossom of dwarf pyramid pear trees at Long Ashton. On this occasion a screen minimum of 27°F was recorded, though it is suspected that lower temperatures than this were reached in low-lying areas of the farm. 1961 was an exceptionally early year and most varieties of pear were already at green cluster stage when the damage occurred. Subsequent development of the blossom appeared normal, but the full extent of the damage was revealed when the flowers opened in early April. Sample counts made on 7 April showed that in Williams' and Laxton's Superb 78 per cent of the blossoms were killed, but the later-flowering Comice escaped serious injury. In addition to the frost damage at green cluster, the weather during the pollination period was very poor, with almost continuous rain ; few insects were seen on the blossom, and it was anticipated that the crop would be very light.

An experiment was therefore designed to investigate the effect of three different concentrations of GA (20, 50 and 100 p.p.m.), applied at two different stages of development (white-bud and full bloom) on the cropping of Williams' and Laxton's Superb pears. In a smaller-scale subsidiary experiment the effect of a wider range of concentrations of GA on the setting of frost-damaged blossom of Bristol Cross pear was investigated.

Experimental.

In the main experiment 128 trees were used. They were 10-year-old dwarf pyramids on Quince A rootstocks, planted at 8 × 4 ft. The experiment was arranged in 8 randomized blocks, with 8 single-tree replicates of each of the following treatments on each variety :

C	Controls	Sprayed with water and wetter only.
B 20	GA 20 p.p.m.	Sprayed at " white-bud," March 28, 8 days after frost.
B 50	GA 50 p.p.m.	
B 100	GA 100 p.p.m.	
F 20	GA 20 p.p.m.	Sprayed at full bloom, April 7, 18 days after frost.
F 50	GA 50 p.p.m.	
F 100	GA 100 p.p.m.	
R 20	GA 20 p.p.m.	Sprayed on March 28 and April 7.

In addition to GA, all sprays contained 0·025 per cent of a non-ionic wetting agent (Ethylan C) and 0·5 per cent glycerol to aid penetration. The sprays were

applied to whole trees by means of small pressurized hand sprayers. On March 28 the weather was dry and sunny with a slight wind. On April 7 it was dull, misty and rather cool and, shortly after spraying was finished, light rain fell and continued for several hours.

The following records were taken :

(1) total number of blossom clusters on each tree.
(2) total number of fruits at harvest time.
(3) number of fruits which fell in the pre-harvest drop.
(4) number of marketable fruits (over 2 inches diameter) and number of culls (less than 2 inches diameter) per tree.

Results.

Williams' (Table 1). As was anticipated, the unsprayed trees set a very light crop which averaged only 5 fruits for every 100 blossom clusters. These were produced mostly on the tops of the trees, where the frost damage had been least severe. All the GA treatments increased the crop though, owing to high tree-to-tree variation, only the F 50 and F 100 treatments were significant at the 1 per cent level of probability. All treatments increased the marketable crop and all except B 20 were significantly better than the controls at the 1 per cent level. The best treatment was 100 p.p.m. GA applied at full bloom, which gave over a four-fold increase in crop, though 50 p.p.m. at full bloom was almost as good. Practically all the fruits produced were of good marketable size, though slightly abnormal in shape, many showing a slight tapering towards the eye which is characteristic of parthenocarpic pears produced by GA (2). This effect on fruit shape was, however, much less pronounced than in the 1959 experiments. About 10 per cent of the crop was lost through pre-harvest drop, but there were no significant differences between the drop from the sprayed and the unsprayed trees. No effects of GA on fruit maturity or on the vegetative growth of the trees were noted.

TABLE I.

EFFECT OF GIBBERELLIC ACID SPRAYS ON CROPPING OF WILLIAMS' PEAR.

Means for 8 trees.

Treatments (see p. 61).

	Control	B20	B50	B100	R20	F20	F50	F100
Number of blossom clusters	716	851	725	765	745	803	1007	1014
Total fruits set per 100 clusters	5·0	8·5	11·0	11·5	12·0	10·9	*14·4*	*17·6*
Marketable fruits per 100 clusters	2·9	6·4	*8·3*	*9·7*	*8·7*	*9·6*	*11·8*	*13·6*
Mean fruit wt. (marketable) (lb.)	0·32	0·31	0·31	0·30	0·30	0·30	0·32	0·31
Drops as per cent total crop	9·6	12·6	14·1	8·8	9·6	5·8	8·6	10·7
Culls as per cent total crop	2·4	2·3	0	0	4·3	0	0	1·3

The values *in italics* differ significantly from the corresponding control values at the 1% level of probability.

TABLE II.

EFFECT OF GIBBERELLIC ACID SPRAYS ON CROPPING OF LAXTON'S SUPERB PEAR.

Means for 8 trees.

Treatments (see p. 61).

	Control	B20	B50	B100	R20	F20	F50	F100
Number of blossom clusters	1409	1421	1067	1272	1432	1392	1451	1463
Total fruits set per 100 clusters	9·4	8·1	14·9	*23·3*	14·8	12·5	*23·3*	*22·1*
Marketable fruits per 100 clusters	3·7	2·6	3·9	*8·2*	5·9	4·6	*9·6*	7·1
Mean fruit wt. (marketable) (lb.)	0·30	0·27	0·25	0·24	0·27	0·29	0·27	0·26
Drops as per cent total crop	23·8	33·2	28·8	11·0	17·4	26·1	21·3	17·4
Culls as per cent total crop	3·5	7·0	*17·0*	*28·0*	*13·2*	*13·7*	*21·4*	*26·9*

The values *in italics* differ significantly from the corresponding control values at the 1% level of probability.

Laxton's Superb (Table II). As with Williams' the GA sprays applied at full bloom were somewhat more effective in increasing fruit set than were the same concentrations applied at white-bud, the best treatment being 50 p.p.m. at full bloom, which increased both the total crop and the marketable crop by a factor of approximately 2½. The increase due to treatment was not quite so spectacular as with Williams' owing to the fact that the unsprayed control trees of Laxton's Superb set a somewhat higher percentage of fruits than did Williams'. The very large differences between the total crop and the marketable crop in Superb is partly due to the fact that harvest was unavoidably delayed, so that many fruits were lost through pre-harvest drop. None of the experimental treatments, however, had any significant effect on the extent of the drop or on the maturity of the fruit. Another feature, which was not encountered with Williams', was the large proportion of undersized fruits on the trees which had been sprayed with GA. As shown in Table II, the percentage of culls (less than 2 inches diameter) increased with increasing concentrations of GA and was generally greater in trees sprayed at full bloom than in those sprayed at white-bud. The marketable fruits, although slightly atypical in shape for the variety, were an acceptable commercial sample.

Effect of GA concentration. A different type of experiment was performed on the variety Bristol Cross, in order to investigate the effect of a wider range of concentrations of GA on the setting of frost-damaged blossoms.

Sixteen dwarf pyramid trees were used on which approximately 50 per cent of the flowers had had their styles killed by the frost. On 14 of these trees all the undamaged flowers were removed and the frosted flowers were thinned out to two per blossom cluster. On the two remaining trees the procedure was the same except that only undamaged flowers were left.

The trees carrying only frosted blossoms were sprayed at full bloom with concentrations of GA ranging from 5 to 200 p.p.m., two trees being sprayed with each concentration. The sprays contained 0·025 per cent Ethylan C and 0·5 per cent glycerol, and the two control trees received a spray containing these

substances only. At harvest the total number of marketable (greater than 2 inches) and cull (less than 2 inches) fruits, and the mean weight of the marketable fruits was recorded. The results are shown in Table III and in Fig. 1, Plate II.

TABLE III.

EFFECT OF GIBBERELLIC ACID ON FRUIT-SET OF BRISTOL CROSS BLOSSOMS.

GA sprays applied on 15 April, 1961.

Type of flower	Conc. of GA (p.p.m.)	No. of flowers treated	% Fruit set			Mean wt. marketable fruits (lb.)
			Marketable	Cull	Total	
Normal	0	238	15·5	3·4	18·9	0·34
Frosted	0	178	7·3	2·3	9·6	0·28
,,	5	188	11·7	2·1	13·8	0·34
,,	10	180	20·0	6·1	26·1	0·34
,,	25	148	16·2	6·8	23·0	0·31
,,	50	156	16·6	12·2	28·8	0·32
,,	100	148	11·5	10·8	22·3	0·30
,,	200	154	7·1	6·5	13·6	0·24

In this variety 9·6 per cent of the frosted flowers set without any treatment : these naturally parthenocarpic fruits, however, tended to be small and misshapen, a high proportion of them being sausage-shaped (Fig. 1). All concentrations of GA increased the percentage set. At the lowest concentration (5 p.p.m.) the increase was small, but there was a very marked improvement in the size and shape of the fruits, both of which were essentially normal for the variety (Fig. 1).

Over the range 10–100 p.p.m. GA there was a substantial increase in fruit set, with no consistent differences between different concentrations. The best quality fruits, as regards size and shape, resulted from the 10 p.p.m. spray. Above this concentration the abnormal tapering of the fruits towards the eye became increasingly apparent, and there was a marked increase in the proportion of undersized fruits in the sample. The least successful spray was the 200 p.p.m. ; at this concentration, not only was the increase in set very small, but the resulting fruits were small and of abnormal shape.

Discussion.

These experiments have confirmed the ability of gibberellic acid, when applied as an overall spray, to improve the cropping of pears in situations where a large proportion of the flowers have been damaged by frost. A noteworthy feature of the experiments was that the most successful treatments were those applied at full bloom, although this did not occur until 18 days after the damaging frost.

On Bristol Cross the best concentration was 10 p.p.m. ; on Superb, 50 p.p.m. ; and on Williams', 100 p.p.m. These different concentration require-

Fig. 1. Parthenocarpic fruits of Bristol Cross produced from frost-damaged flowers treated with gibberellic acid (see p. 63).

Fig. 2. Merton Bountiful. *Above.* Normal seeded fruits. *Below* fruits produced by spraying open-pollinated flowers with 50 p.p.m. gibberellic acid.

ments may reflect differences in varietal response to GA, though it is more probable that they are related to the leaf area exposed at the time of spraying. In Bristol Cross it was noted that the spur foliage was well developed and that the trees appeared quite green at the time of full bloom. In Laxton's Superb the spur leaves were partially unfolded at full bloom, but Williams' flowered on practically bare wood. Assuming, as seems probable, that the leaves are the most efficient absorbing organs for GA, the same explanation may account for the generally smaller effect of a given concentration when applied at white-bud stage as compared with the full bloom application.

The experiments with Laxton's Superb and Bristol Cross indicate that supra-optimal concentrations of GA are less effective in increasing fruit set and markedly increase the percentage of undersized fruits in the crop. Fruit shape also becomes progressively abnormal as the concentration is increased. As mentioned in a previous paper (2), GA has the effect of stimulating the calyx end of the fruit to a relatively greater extent than the stalk end, so that the fruits tend to be more elongated than normal and often show an excessive puckering around the eye. This effect is particularly pronounced on the variety Merton Bountiful (Fig. 2). There is also some increase in the length of the fruit stalks. However, these abnormalities were considerably less pronounced in 1961 than in the previous experiments in 1959 and, provided the concentration used did not exceed 50 p.p.m., the fruits produced were of acceptable market quality.

Griggs and Iwakiri (1), reporting on the application of GA sprays to Williams' (Bartlett) pears in California, mention that such sprays may cause the death of the growing points of vegetative shoots arising from the spurs, and that this may be followed by the development of spines, and by reduced fruit bud formation. No such effects have been observed to result from spraying pears with GA at Long Ashton, and the vegetative growth of the trees appears quite normal.

Although further experience with these sprays is obviously required, it appears from these experiments that GA may prove of considerable value to the fruit grower for ensuring a full crop of pears in seasons when the blossom has been partially or totally destroyed by frost.

Summary.

(1) Aqueous solutions of gibberellic acid (GA) containing a wetting agent and glycerol were sprayed on to trees of Laxton's Superb and Williams' pears on which 78 per cent of the blossoms had been damaged by frost.

(2) The best treatment on Williams' (100 p.p.m. at full bloom) gave a four-fold increase in marketable crop. On Superb (50 p.p.m. at full bloom) the marketable crop was increased $2\frac{1}{2}$ times.

(3) On Superb, but not on Williams', GA sprays increased the proportion of fruits less than two inches in diameter.

(4) On frosted flowers of Bristol Cross, concentrations of GA varying from 5–200 p.p.m. were effective in increasing fruit set, the best concentration being 10 p.p.m.

(5) Supra-optimal concentrations of GA were less effective in increasing fruit set, and gave smaller fruits than did optimal concentrations. Fruit shape also became progressively abnormal as concentration was increased.

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THE AFTER-RIPENING OF APPLE SEEDS IN THE FRUIT DURING COLD STORAGE.

By C. E. C. BARTLETT.

Introduction.

Apple seeds will not normally germinate readily until they have been after-ripened under moist conditions at low temperature. At the optimum temperature of 4°C the after-ripening period of fully imbibed seeds is about 14 weeks. The experiment described below was undertaken to find to what extent the seeds of apples held in cold storage will after-ripen in the fruit. The temperatures used for cold storage of apples are close to the optimum temperature of after-ripening, but the water content of the seeds is normally well below the point of full imbibition. The investigation was prompted by the work of Phillips and Poapst (3) who postulated that the development of ' core flush ' in certain Canadian varieties of apple held in cold storage was correlated with the after-ripening of the seeds, and suggested as a causal factor the flush of auxin production which occurs in the seeds when after-ripening is complete (2).

Experimental.

25 bushels each of Bramley's Seedling, Cox's Orange Pippin and Laxton's Superb apples were placed, immediately after harvest, in a cold store at 4°C. 1500 seeds were removed from fruits of each variety and, after soaking in water for 3 days at room temperature, these were placed in petri dishes on moist cotton wool and returned to the cold store to after-ripen. The course of after-ripening in this control series of seeds was followed by taking samples of 100 seeds at 14-day intervals, and placing them on moist cotton wool in an incubator at 17°C, as recommended by Abbott (1). The germination percentage was measured after 10 days.

At the same intervals 100 seeds were removed from the stored fruits of each of the three varieties, and these were germinated under the same conditions. Any incidence of core flush was noted in the cut fruits.

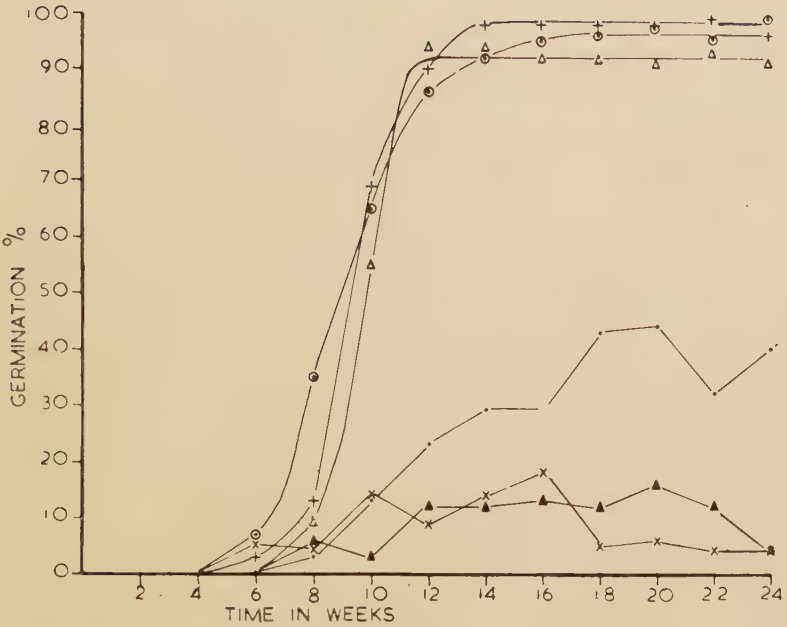

Fig. 1. Percentage of seeds germinated after 10 days at 17°C. Upper three curves—excised seeds after-ripened at 4°C on moist cottonwool; lower three curves—seeds taken from fruits stored at 4°C. + × = Cox's Orange Pippin; ○ • = Bramley's Seedling; △ ▲ = Laxton's Superb.

Results.

The results, presented in Fig. 1, show that very little after-ripening of the seeds occurred in fruits of Cox and Laxton's Superb held in cold storage at 4°C. In Bramley's Seedling some slow after-ripening occurred, but even after 24 weeks the germination percentage was less than half that of seeds which had been after-ripened outside the fruit. Core flush was apparent in Bramley's Seedling and Cox from the 20th week, and in Laxton's Superb from the 22nd week of storage.

Conclusions.

Abbott (1) has shown that the water content of the seed is an important factor in after-ripening of apple seeds, and the lack of after-ripening, or very slow after-ripening, of seeds within apples held at 4°C in cold storage is almost certainly attributable to the fact that they are not fully imbibed with water.

The occurrence of " core flush " in Cox and Laxton's Superb in the absence of appreciable after-ripening of the seeds lends no support to the hypothesis of Phillips and Poapst that these two phenomena are related.

Acknowledgments.

I wish to thank Dr. L. C. Luckwill and Mr. D. L. Abbott for help and interest in this work.

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APOMICTIC SEEDLING ROOTSTOCKS FOR APPLES: PROGRESS REPORT III.

By A. I. CAMPBELL and D. WILSON.

Uniformity is the key factor in the potential development of seedling progenies from apomictic *Malus* species as cheap, virus-free rootstocks for apple trees (1, 2, 3). Some variation is to be expected since Oldén (4) and Sax (5) showed these *Malus* species to be facultative apomicts, producing seed both apomictically and sexually. Luckwill and Campbell (3) reported that in open pollinated progenies from *Malus hupehensis* (Pamp.) Rehd., *M. toringoides* Rehd. and *M. sikkimensis* (Hook f.) Koehne some 3–5 per cent of the seedlings were dwarfed and thought to be tetraploid. Recent experience suggests, however, that in some progenies the proportion of deviants is higher than 5 per cent. The degree of uniformity likely to be found in *M. hupehensis* and *M. toringoides* after various pollination treatments was therefore investigated in the following experiment.

Experimental.

The parent trees of *M. hupehensis* and *M. toringoides* used in this experiment were part of a small collection of *Malus* species growing at Long Ashton. In the spring of 1959, groups of 100–160 flowers of both species were treated in the following ways :—

(1) *Low emasculated and effeminated.* Perianth, styles and stamens were removed at balloon stage by a single cut at the top of the ovary.

(2) *Cross pollinated.* Flowers were hand-pollinated with a mixture of pollen from the apple varieties Laxton's Superb, Exeter Cross and Sweet Alford.

(3) *Open pollinated.*

(4) *Selfed* (*M. hupehensis* only). Entire flower clusters were protected from foreign pollen by pergamine bags throughout the flowering period. Since *M. hupehensis* produces little if any pollen, this treatment was virtually one of non-pollination.

Records of fruit-set, seed content and seed germination were taken. Visual assessments of variability were made at intervals while the young seedlings were in the greenhouse and a further inspection was made 15 months after they had been planted in the field.

Results.

Table I shows the percentage fruit-set, mean number of seeds per fruit and percentage seed germination. It can be seen that, in both species, fruit-set was low after emasculation and effemination. That this may have been due to mechanical injury of the flowers rather than to the lack of pollination is suggested by the high percentage set obtained in the selfed treatment. In *M.*

Fig. 1. *M. toringoides.*
Left—Two shoots from apomictic seedlings. *Right*—Two shoots from aberrant seedlings.

Fig 2. *M. hupehensis.*
Left.—Two shoots from apomictic seedlings. *Right*—Two shoots from aberrant seedlings.

TABLE I.

FRUIT-SET, SEED NUMBER, SEED GERMINATION AND PERCENTAGE OF ABERRANT SEEDLINGS IN *Malus hupehensis* AND *M. toringoides* AFTER VARIOUS POLLINATION TREATMENTS.

Species	Treatment	Number of flowers treated	% Fruit harvested	Mean number of seeds per fruit	% Seed germination	% Aberrant seedlings (2nd year)
hupehensis	Low emasculated and effeminated	100	4	1·25	80	0
,,	Selfed	100	74	1·19	75	2
,,	Cross pollinated	100	65	1·37	75	37
,,	Open pollinated	—	—	1·83	88	57
toringoides	Low emasculated and effeminated	160	8	2·00	38	0
,,	Cross pollinated	160	72	1·83	52	78
,,	Open pollinated	—	—	1·85	88	54

toringoides there was very little difference between the mean seed numbers but in *M. hupehensis* the mean seed number was somewhat higher from open-pollination than from other treatments. Seed germination in *M. hupehensis* was adequate and did not vary to any great extent with treatment. In *M. toringoides* the open-pollinated seed gave a higher percentage germination than did the cross-pollinated seed, which in turn was slightly better than that from the sterilized flowers (Treatment 1).

Inspection of the seedlings prior to planting in the field showed that in all treatments there was a small amount of variation in vigour and a slight indefinable difference in leaf shape. At this stage the only recognizable differences were in seedlings from open-pollinated seed of *M. toringoides* of which 6 per cent were dwarf and had broader, less divided leaves, and from selfed seed of *M. hupehensis* of which 2 of the 54 seedlings were also dwarf.

After 15 months in the field all the seedlings from Treatment 1, necessarily apomictic, were uniform in size and shape. Other treatments gave rise to varying numbers of seedlings different from the apomicts and presumably sexual hybrids. In *M. toringoides* the hybrids had larger leaves less divided than the apomicts (Plate III, Fig. 1) ; in *M. hupehensis*, although the difference was not so marked, the hybrids were readily recognizable in the field by their larger and flatter leaves (Fig. 2). As expected, seedlings from selfed *M. hupehensis* were uniform, with only 1 out of 50 seedlings not true to type ; with cross- and open-pollination the numbers of aberrant seedlings were respectively 18 out of 49 and 28 out of 49 (Table I). With *M. toringoides* 39 out of 50 cross-pollinated and 27 out of 50 open-pollinated seedlings were aberrant.

Discussion.

These results make it obvious that the flowers of *M. hupehensis* and *M. toringoides* require protection from foreign pollen if uniform apomictic seedlings are to be obtained. The experiments also show that *M. hupehensis* will set an

adequate crop of fruit in isolation from other pollen, and other experience has indicated that the same applies to *M. toringoides* and *M. sikkimensis*. Even when the flowers were protected from other pollen, as in the selfed treatment of *M. hupehensis*, 3 of the 52 seedlings were off-type, but here two were recognizable at a very early stage. Such was not the case in other treatments, where the majority of deviants did not become apparent until the second year of growth. In most seasons the late flowering habit of the apomicts considerably reduces the possibility of cross-pollination, but spatial isolation from other *Malus* species or mechanical isolation by caging would undoubtedly be more effective.

Most of the variation so far recorded has been in leaf morphology, and it is not known whether there will be a comparable variation in the vigour of trees grown on these seedling rootstocks. To investigate this all the seedlings have now been budded with Lord Lambourne.

Summary.

The degree of variation has been studied in seedlings of *Malus toringoides* and *M. hupehensis* produced by emasculating and effeminating, selfing, open-pollinating or cross-pollinating the flowers. The selfed flowers gave a very high proportion of apomictic seedlings uniform with those obtained from sterilized flowers. Open- and cross-pollination produced 22–63 per cent apomicts and 37–78 per cent aberrant (hybrid) seedlings, whose leaf characters could usually be distinguished from those of the apomicts only in the second year of growth. The production of uniform seedlings therefore calls for the exclusion of foreign pollen either by isolating the trees from other *Malus* species or by bagging the flowers.

Acknowledgments.

We wish to thank Miss M. W. Shellard for her assistance in recording, and Mr. C. S. Gundry and Mr. J. S. Coles for raising the seedlings in greenhouse and nursery respectively.

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THE TIME FACTOR IN APPLE VIRUS TRANSMISSION.

By A. I. CAMPBELL and J. S. COLES.

Grafting and bud-grafting are the chief and perhaps the only means by which apple viruses are spread in the nursery and orchard. However, in experiments on virus transmission and in nursery practice it has frequently been observed that a successful graft union is not necessary for virus transmission, and that a virus can sometimes pass from an infected scion to a rootstock, or vice versa, even when the two parts of the graft are united by only a small amount of callus. The following experiment was therefore carried out to determine the minimum time required for some apple viruses to pass from an infected bud-graft to a healthy rootstock.

Experimental.

Six blocks of fifty apple seedling rootstocks, presumed to be free from all viruses, were planted in November 1959. Three blocks were bud-grafted in July 1960, five inches above soil level, with buds of the virus-sensitive variety Lord Lambourne, taken from a mother tree free from apple mosaic. At the same time, two inches under these buds and on the same side of the stock, inoculation buds of Lord Lambourne carrying a severe strain of apple mosaic were inserted.

The other three blocks were bud-grafted in July 1960 with the virus indicator *Malus platycarpa*, free from all known viruses, and under these buds were inserted inoculation buds from the clonal rootstock M.XXV infected with chlorotic leaf spot (line pattern), dwarfing and scaly bark.

The fifty rootstocks in each block were sub-divided into ten plots of five trees. The inoculation buds in each plot were removed and destroyed one hour, two hours, four hours, one day, two days, four days, one week, two weeks, or four weeks after bud-grafting. These nine treatments plus an uninoculated control were randomized within each block.

During the summer of 1961, virus symptoms were recorded at monthly intervals on the indicators Lord Lambourne and *M. platycarpa*. At the end of the year the height of the indicators and their girth at five inches above the union were measured.

Results.

The incidence of virus symptoms is shown in Table I. It will be seen that apple mosaic, chlorotic leaf spot, dwarfing and scaly bark viruses can all pass easily and quickly from an infected bud to a healthy rootstock.

Although only one of the thirteen trees inoculated with severe apple mosaic in the one-day treatment was infected, it was obviously possible for transmission to occur long before a successful union or even callus formation was apparent. Transmission usually took place during the first and second week after inoculation ; by the end of this period, nine of the ten trees were infected with mosaic (Table I). After four weeks the percentage infection was no higher, but this may have been due to the inadvertent use of some mosaic-free buds ; a small proportion of these have been shown to occur with this virus, which is not always fully systemic (1).

Chlorotic leaf spot virus was transmitted in almost as short an interval as apple mosaic. Two days after inoculation the virus had passed into one rootstock, and it can be seen that the number of trees infected increased steadily to 93% in the two-week and 100% in the four-week treatment, suggesting that this virus is fully systemic.

The number of trees infected with chlorotic leaf spot virus was higher than that infected with *platycarpa* dwarf and scaly bark viruses (Table I), especially in the first week, and in no instance was either of these viruses transmitted

TABLE I.

SYMPTOMS OF *Malus platycarpa* INOCULATED FOR DIFFERENT TIMES WITH CHLOROTIC LEAF SPOT, SCALY BARK AND DWARFING VIRUSES AND OF LORD LAMBOURNE INOCULATED WITH A SEVERE STRAIN OF APPLE MOSAIC.

Period of contact with infected buds	*Malus platycarpa*				*Lord Lambourne*	
	No. of trees	Chlorotic leaf spot (Line pattern)	Scaly Bark	Dwarf (Trees under 50 cm.)	No. of trees	Mosaic
1 hour ..	12	–	–	–	13	–
2 hours ..	13	–	–	–	13	–
4 hours ..	11	–	–	–	13	–
1 day....	15	–	–	–	13	1
2 days ..	13	1	–	1	11	1
4 days ..	11	3	1	2	14	–
1 week ..	13	6	–	1	14	6
2 weeks..	12	11	8	9	10	9
4 weeks..	13	13	12	10	14	10
Control	*9*	–	–	–	*12*	–

without chlorotic leaf spot. Although a small proportion of the plants in the two-day, four-day and one-week treatments showed symptoms of *platycarpa* dwarf and scaly bark viruses, most of the infection took place after the second week, when some vascular union might have been expected. It therefore appears that a slightly longer time interval after inoculation is usually needed for the transmission of *platycarpa* dwarf and scaly bark than for chlorotic leaf spot virus.

Since symptoms, particularly of apple mosaic, sometimes do not appear until the second year, the number of infected trees may ultimately be greater than that shown in Table I.

Discussion.

It is evident from this experiment that some apple viruses such as mosaic and chlorotic leaf spot can pass from an infected scion to a rootstock in one or two days. Since no visible callus union is formed during this time, it is tempting to speculate whether these viruses may not reach the rootstock in the form of infected sap from the cut surface of the scion. Although these viruses are not sap transmissible by the usual techniques it seems possible that they may become so under conditions where the polyphenoloxidase is inhibited by anaerobic conditions such as may exist in a newly made graft.

Other viruses such as *platycarpa* dwarf and scaly bark apparently take somewhat longer to pass from scion to stock, which suggests that it might be possible to use this technique to separate certain apple viruses which normally occur in combination.

From the point of view of the nurseryman these experiments emphasize the dangers of reworking rootstocks in which the bud has failed. In view of the widespread occurrence of viruses in commercial clones of fruit trees, any rootstock which has been bud-grafted, even if the bud has failed to take, will almost certainly have been infected with one or more viruses. If these stocks are subsequently worked with another variety, the viruses will be transmitted to the second variety. This bad nursery practice has, in the past, almost certainly been responsible for the spread of viruses from one variety to another. Where such stocks must be reworked they should be bud-grafted only with scion material from the mother tree originally used.

Summary.

The apple viruses, mosaic, chlorotic leaf spot, *platycarpa* dwarf and scaly bark were transmitted from an infected bud-graft to a healthy rootstock in a few days and long before any callus union was apparent.

Apple mosaic transmission occurred in one day but usually took one or two weeks; chlorotic leaf spot, *platycarpa* dwarf and scaly bark were also transmitted after similar short periods.

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TECHNIQUES USED IN THE INACTIVATION OF SOME APPLE VIRUSES.

By A. I. CAMPBELL.

Introduction.

The observation that some tree-fruit viruses common in this country can cause reduction in yield (1,2) has emphasized the advisability of planting virus-free trees. Recent work has shown that it is possible to select clones of apple varieties and rootstocks free from some viruses (3) and, as a result, trees of many of the main commercial dessert, culinary and cider apples, free from apple mosaic, rubbery wood and chat fruit viruses, are now available to growers and nurserymen.

The presence of other apple viruses which show no symptoms on rootstocks and varieties has been demonstrated by the use of indicator plants such as Virginia Crab, Spy 227 and *Malus platycarpa*. Some of these latent virus infections have been shown to be widely distributed (4) and, since no virus-free source of many of the popular varieties and rootstocks has been found, it has been necessary to try to inactivate the viruses.

Of various methods of virus inactivation the most widely employed has been some form of heat treatment. Hot water baths, hot ovens and hot air cabinets have all proved successful for the inactivation of viruses in a range of plants which includes strawberries, raspberries, peaches, apples and cherries.

Steere (5) showed that virus multiplication is slower at higher temperatures, and 36°–40°C has been found to be the most suitable for virus inactivation in many plants. Posnette & Cropley (6) found that apple mosaic virus could be inactivated by 27 days heat treatment at 38°C.

The present experiments were particularly concerned with the inactivation of chlorotic leaf spot, scaly bark and dwarfing viruses which induce symptoms in *Malus platycarpa* but are latent in commercial varieties and clonal rootstocks.

Experimental.

Heat Therapy Cabinet

The controlled temperature cabinet used in these experiments was designed and made at Long Ashton. It was constructed of wood ; it measured 6 ft. long by 3 ft. wide and 5 ft. high and was mounted on a low trolley frame of slotted steel angle. The growth compartment of 72 cubic feet was double-glazed on the sides and top and contained a thermostat and a small air-mixing fan. Beneath this compartment two longitudinal sheet-metal ducts, each with a small fan and two 300 W strip-heaters connected to the thermostat and relay, circulated air at the pre-set temperature through slots at each end of the growth compartment. This two-way circulation and the vertically-mounted mixing fan created sufficient air turbulence over the plants to prevent undue temperature gradients. Small grilles were placed at each end of the cabinet to admit a controlled quantity of fresh air.

Heat Treatment

The temperature was controlled at 37° ± 2°C, the relative humidity varying between 40 and 50 per cent. The natural light intensity was increased, by two 400 W mercury vapour lamps suspended over the cabinet, to about 800 lumens per square foot at plant height, and daylength was increased to 16 hours per day during the winter months.

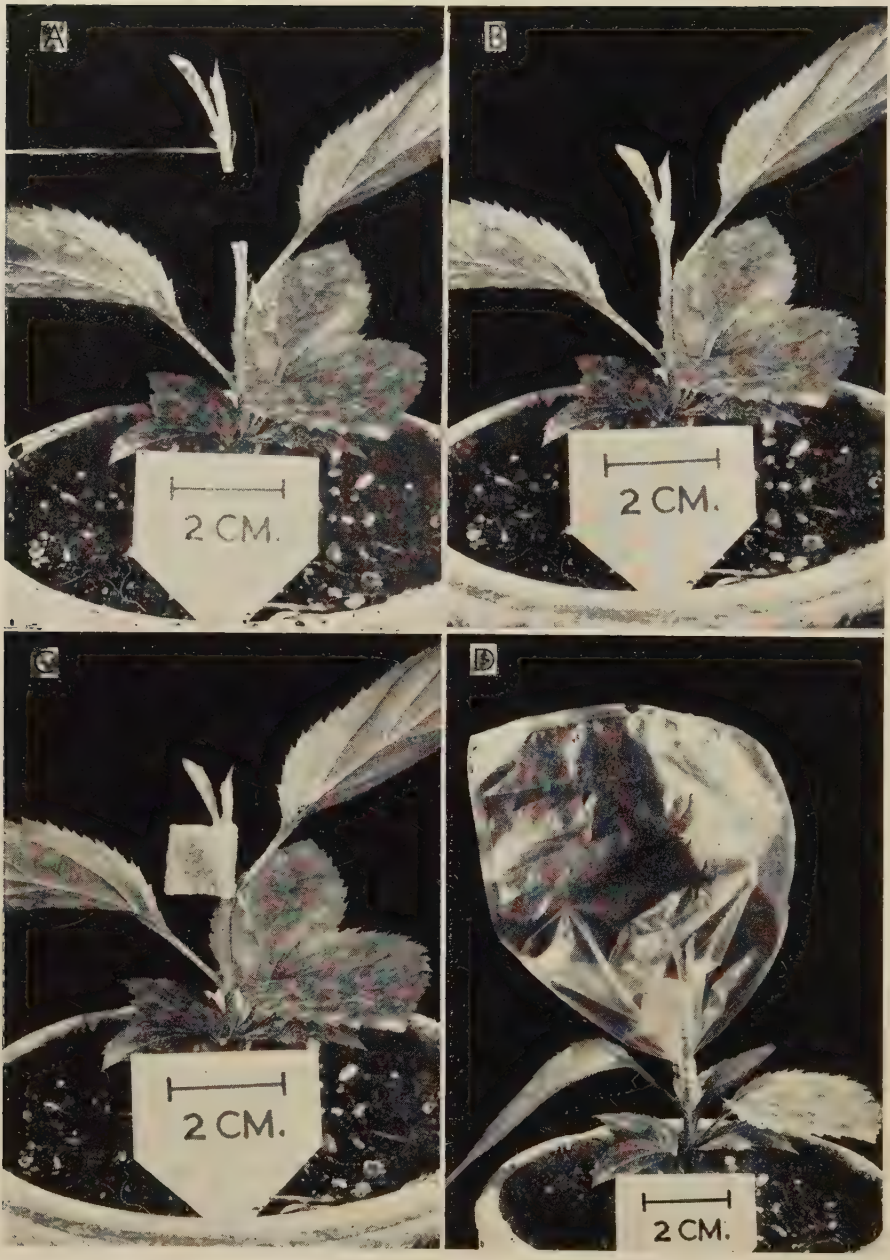
One-year-old apple trees free from mosaic, rubbery wood and chat fruit but infected with chlorotic leaf spot, scaly bark and dwarfing viruses were subjected to hot air treatment for periods of 10, 15 or 20 days. The trees made rapid growth in the cabinet and by the end of 20 days some extension shoots had grown 12″ or more. As soon as the heat treatment was completed, buds from near the top of these shoots were re-tested on seedling rootstocks, using the double-budding method of virus indexing with *Malus platycarpa* as the indicator.

The results suggested that some reduction in the amount of virus had been achieved, since the top buds from the heat-treated shoot were initially less heavily infected than the lower ones. This initial improvement was not maintained, however, and systemic re-infection was rapid. The need for a longer period of treatment or for the isolation and propagation of the growing point after treatment was obvious.

Tip Propagation after Heat Treatment

Various methods of isolating the growing tip from the heat-treated plant to prevent re-infection from the virus in the deep-seated tissue were tried. They included various forms of grafting and mist propagation. All were partially successful, but one, similar to that described by Garner (7), proved

PLATE IV.



A. Scion with two cuts forming wedge : stock with top removed and cut vertically.
B. Scion in position in stock.
C. Stock and scion held together by strip of self-adhesive crêpe bandage.
D. Graft enclosed in polythene bag and secured by wire clip.

superior to the others. In this method the extreme tip (1 cm.) of the treated shoot was removed and wedge-grafted into a young apple seedling (Plate IV, Figs. 1 and 2). The stock and scion were held in place by a strip of self adhesive surgical crêpe bandage (Fig. 3) and the graft was enclosed for 10 days in a small polythene bag, secured by a wire clip (Fig. 4).

Results.

The growth of the young tip was rapid once a union had been made, and under spring and summer greenhouse conditions many tips grew a foot or more in two months, and the number of failures was less than 5%. Tip growth during the autumn and winter was less and the casualties increased, but this technique could nevertheless be used at all seasons.

Buds from the extension shoot produced from the tip were later re-tested, again using *M. platycarpa* as the indicator. The results obtained with some of the varieties treated for 20–30 days are shown in Table I. It can be seen that many of the clones tip-propagated after 20 days heat-treatment were free from chlorotic leaf spot, scaly bark and dwarf viruses, and that additional time in the cabinet did not necessarily improve the results. Since tips from control plants not heat-treated were still infected when re-tested it would appear that both heat treatment and tip propagation are necessary for the elimination of these viruses.

TABLE I.

VARIETIES IN WHICH LATENT VIRUS INFECTIONS HAVE BEEN INACTIVATED.

Variety	Heat Treatment		No. of healthy trees (tested on *M. platycarpa*)
	No. of trees	No. of days	
Allington Pippin	3	20	3
,, ,,	6	23	6
Beauty of Bath	7	23	3
Bramley Seedling	5	20	3
Cheddar Cross	3	28	3
Egremont Russet	8	20	4
,, ,,	5	23	5
Ellison's Orange	3	23	3
Emneth Early	4	20	4
Exeter Cross	4	23	4
Lane's Prince Albert	3	23	2
Laxton's Superb	5	20	5
,, ,,	4	23	4
Merton Beauty	5	23	2
Newton Wonder	2	20	2
Ribston Pippin	3	30	3
Sturmer Pippin	8	20	3
,, ,,	3	23	–
Winston	3	23	3
,,	8	30	8
Worcester Pearmain	10	20	5
,, ,,	7	23	–

Discussion.

The success of the heat treatment appeared to be related more to the rate of growth of the plant, while in the cabinet, than to the duration of the treatment : the tips from some plants were freed of the viruses after only 20 days whereas others of the same variety were still infected after 30 days. Posnette and Cropley (6) similarly found with apple mosaic that inactivation was not correlated with the duration of heat treatment, though with this virus it was possible to obtain mosaic-free buds from the extension shoots without tip propagation.

Periodic tests will be necessary to confirm that the clones remain free from infection, since it is possible that some re-infection from deep-seated virus may still occur. It is also possible that the virus concentration has only temporarily been reduced to a level at which no symptoms appear on the indicator plant. Since the interval between heat-treatment and symptom expression after testing inevitably takes 18 months, neither of these possibilities seems likely.

Although the percentage of apparently healthy clones has so far been low, the technique need be successful in only one individual of each variety and rootstock. Clonal descendants should remain free from these viruses indefinitely if graft union with infected material is avoided, since there is as yet no evidence that the viruses spread by any other means.

Further work will be necessary to compare the performance of heat-treated and virus infected clones of commercial varieties of apple. Preliminary results with apple seedlings (8) suggest that varieties will show varying degrees of sensitivity to infection.

Acknowledgments.

Thanks are due to Mr. S. E. Cole, Mr. E. A. Fribbins and Dr. N. G. Morgan for the design and construction of the heat cabinet, to Mr. C. S. Gundry and Mr. J. S. Coles who raised the plants in the greenhouses and nursery respectively and to Miss M. W. Shellard for assistance in recording the experiments. The photographs were taken by Mr. P. F. Rushby.

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CIDER APPLES AND THEIR CHARACTERS.

By R. R. WILLIAMS and R. D. CHILD.

Few of the cider apple varieties planted in present day orchards of the West Country are described in those pomological works that include vintage fruits. These illustrated descriptions are intended to facilitate the identification of varieties and the selection of varieties for new plantings. Fruit descriptions are given in considerable detail, for many of the characters are of diagnostic value : leaf characters have been found too variable to be of use and have therefore been omitted.

Most of the terms used in describing the fruits are self-explanatory, with the possible exception of those describing the core. These are taken from Hogg (1) and explained on page 79. The fruit descriptions cover typical samples from normal mature trees carrying a fair to good crop. In instances where fruits from " off-year " or very young trees are often atypical the main differences have been noted.

The figures given with each description contain drawings of typical fruits in longitudinal section.

Varieties have been classified into six categories according to flowering period. These groupings are such that a variety may cross-pollinate any other in the same or adjacent categories. Anyone wishing to utilize cross-pollination between cider and dessert or culinary varieties should note that the dates of full bloom in an average season are as follows : early, up to 30 April ; early-mid, 1-5 May ; mid, 6-11 May ; late-mid, 12-15 May ; late, 16-22 May ; very late, 23 May onwards.

The juice analyses quoted here are dealt with in more detail in an accompanying paper (2).

Ashton Brown Jersey.

Fruit : Size medium, rarely small. Shape blunt-nosed conical, sometimes approaching cylindrical ; tendency to round base. Stem projecting slightly, occasionally level with base ; frequently fleshy. Stem basin shallow, tending to deep ; very regular. Eye basin shallow or slight ; not steep-sided ; sometimes slightly puckered or slight trace of corona. Calyx closed or slightly open. Sepals reflexed at tips ; sometimes green. Skin a little rough, dull appearance ; yellow or yellowish green. Flush always present ; always more than one-third, sometimes more than two-thirds ; flecked or slightly striped, rarely diffuse only ; dark red flecks or stripes on widespread background of golden yellow or orange. Russet slightly spreading, sometimes considerable, forming a network on cheek, occasionally stem basin only. Lenticels conspicuous ; often very large and irregular, particularly around stem. Scab-resistant. Tube conical ; stamens median. Core slightly proximal ; usually axile, loculi slightly open ; loculi small, obovate, occasionally round, rarely elliptical. Seeds numerous ; brown, large and fat, filling loculi. Flesh yellowish or white, sometimes greenish ; woolly ; sweet and astringent. Harvest 2nd week November onwards ; milling over period of more than 3 weeks.

Juice : Specific gravity 1.054 ; acidity 0.14 ; tannin 0.23.

Cider : Medium bittersweet ; soft and full-bodied.

Flowering : Mid-season ; diploid and a good pollinator.

Notes : Slow to come into cropping. An un-named variety found in an old cider orchard at Long Ashton in the early part of the century. As the juice had some characters in common with the Somerset Jersey apples, it was called Ashton Brown Jersey.

Bulmer's Norman.

Fruit : Size medium or large. Shape conical, sometimes flattened conical ; somewhat irregular. Stem usually projecting slightly, sometimes distinctly, sometimes level with base ; thin and woody. Stem basin wide and very deep. Eye basin deep or very deep, occasionally shallow ; usually irregular, sometimes slightly puckered, sometimes pubescent at base. Calyx usually slightly closed, sometimes slightly open. Sepals short and pubescent. Skin smooth and slightly waxy ; yellow to green. Flush rare ; slight ; diffuse ; orange ; sometimes associated with damage or russet in stem basin, if so spotted or diffuse, red. Russet confined to stem basin, rarely slightly spreading to cheek ; often heavy and scaly, sometimes cracked. Lenticels sometimes large and irregular, sometimes conspicuous on yellow fruits. Scab-susceptible. Tube usually conical; stamens median. Core median or slightly distal; usually abaxile, often axile with open loculi; loculi round, sometimes obovate. Seeds few; brown. Flesh white; woolly ; sweet and astringent. Harvest 2nd-3rd week October ; milling from harvest up to 3 weeks.

Juice : Specific gravity 1.053 ; acidity 0.24 ; tannin 0.27.

Cider : Medium bittersweet ; hard and bitter tannin. Fast fermenting juice.

Flowering : Early mid-season ; triploid and a poor pollinator.

Notes : Cropping very good, biennial. " Off-year " fruits are larger, more irregular, ripen up to 10 days earlier and have a shorter milling season. Young trees produce very large irregular fruits. When the Herefordshire cider company of H. P. Bulmer & Co. Ltd. began to establish orchards in the early part of this century many trees were imported from Normandy, some of which were un-named. One of the un-named varieties was of outstanding orchard performance and was subsequently propagated and distributed to local growers under the name " Bulmer's Norman " after enquiries in France had failed to put a name to the variety. Bulmer's Norman is now grown throughout the West Country and is also at present the best stembuilder variety available to the nurseryman.

Court Royal.

Fruit : Size large, occasionally medium. Shape flattened spherical, sometimes oblate, sometimes irregular. Stem within cavity ; fleshy and thick. Stem basin wide ; shallow to deep. Eye basin usually very deep, sometimes deep ; smooth ; sometimes irregular. Calyx always open, usually upright. Sepals free ; fairly long, base frequently green. Skin smooth with very little wax ; yellow or greenish yellow. Flush always present ; usually approaches two-thirds ; flecked, occasionally striped, rarely diffuse only ; flecks dark red, diffuse flush, orange. Russet on stem basin only, often only slight. Lenticels sometimes conspicuous ; if so, large and irregular, often surrounded by white patch if near stem basin, or by green patch sometimes very dark if on cheek.

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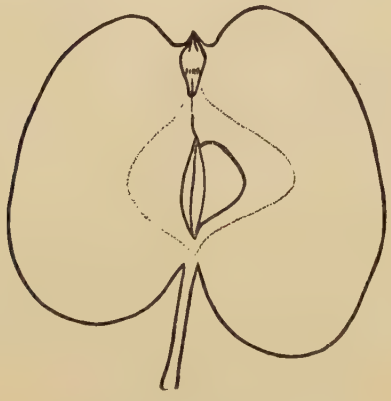
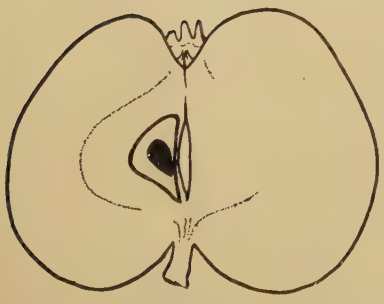
ASHTON BROWN JERSEY



BULMER'S NORMAN



COURT ROYAL

DABINETT

Scab-susceptible. Tube usually conical and shallow, rarely tending to funnel; stamens definitely proximal; pronounced wavy demarcation of tube below sepals. Core median; axile, loculi sometimes open; loculi slightly obovate. Seeds: number variable, usually less than 7; brown. Flesh white, rarely greenish; slightly crisp; sweet not astringent. Harvest 1st—3rd week November, but fruits commence falling in early October; milling from harvest up to 3 weeks.

Juice: Specific gravity 1.050; acidity 0.21; tannin 0.11.

Cider: Pure sweet; fast fermenting juice.

Flowering: Early; triploid and a poor pollinator.

Notes: Cropping fairly good, biennial tendency. Young trees slow to bear. Mature trees of this variety are to be found throughout Somerset and East Devon. At the beginning of the century it was used as a dessert apple in many industrial areas and followed Morgan Sweet in the markets. To-day it is used almost entirely for cider production.

Dabinett.

Fruit: Size medium, sometimes small. Shape flattened conical, sometimes round, regular. Stem projecting slightly, sometimes distinctly; thin and woody. Stem basin small; narrow at base, sometimes shallow, particularly in king fruits. Eye basin usually slight and shallow; slightly puckered or smooth. Calyx tightly closed, sometimes slightly open. Sepals short. Skin smooth and waxy; yellow or greenish yellow. Flush always present; usually more than two-thirds; flecked or slightly striped with extensive diffuse background; dark red. Russet on stem basin only or slightly spreading to cheek. Lenticels usually not apparent, sometimes large corky and conspicuous. Scab-resistant. Tube conical; stamens distal. Core median; abaxile, sometimes axile with loculi open; loculi obovate, often round. Seeds numerous; dark brown. Flesh slightly greenish or white; slightly crisp; sweet and astringent. Harvest 1st week November onwards; milling over period of more than 3 weeks.

Juice: Specific gravity 1.057; acidity 0.18; tannin 0.29.

Cider: Full bittersweet; soft and full-bodied.

Flowering: Late mid-season; diploid, self fertile and a good pollinator.

Notes: Precocious, cropping very good. The variety originated in the Martock-Kingsbury area of Somerset and was probably named after a Mr. Dabinett, for this is a fairly common name in South Somerset. It is one of the Somerset Jersey apples and has been held to be a seedling of the older Chisel Jersey. Growth is comparatively weak, and good land and a strong stem-builder are necessary. Trees appear to have a restricted life and this may be associated with a high level of virus infection. In recent years the variety has been widely planted over the West Country.

Kingston Black.

SYN. BLACK TAUNTON.

Fruit: Size medium, often small. Shape variable; basic shape conical or flattened, tendency to cylindrical. Stem within cavity or level with base, rarely slightly projecting; medium thickness but short thick fleshy stems are common. Stem basin rather narrow; shallow, sometimes deep. Eye basin well defined, shallow or deep; rather steep-sided; sometimes slightly puckered.

Calyx slightly open. Sepals free. Skin dry, no wax, slightly roughened ; yellow-green. Flush always present ; always more than two-thirds, often complete ; flecked or slightly striped, rarely diffuse only ; dark red. Russet slightly spreading to cheek, sometimes considerable, sometimes forming a network over cheek, rarely confined to stem basin ; usually slightly scaly in stem basin. Lenticels conspicuous ; large irregular, often surrounded by a light area. Scab : very susceptible. Tube conical ; stamens medium. Core slightly proximal or median ; axile, loculi often open ; loculi rather small, obovate or sometimes round. Seeds numerous, rather small, sometimes filling loculi ; brown. Flesh reddened, sometimes white ; dry sometimes floury ; mildly sharp, dessert character, but some astringency often noticeable. Harvest 1st—2nd week November ; milling over period of more than 3 weeks.

Juice : Specific gravity 1.061 ; acidity 0.58 ; tannin 0.19.

Cider : Bittersharp ; full bodied ; sometimes with distinctive flavour ; slow fermenting juice.

Flowering : Mid-season ; diploid and a good pollinator. Flowers rather small, often malformed.

Notes : Cropping usually only fair. Probably named after the village of Kingston, near Taunton. Plantings have been sporadic and largely confined to farms where there was an interest in the production of good quality cider; previously described by Hogg and Bull (4, 5). The variety was the subject of a survey of orchard behaviour begun in 1929 by J. E. Forshaw (3). Propagation has now virtually ceased in favour of heavier-cropping varieties less susceptible to canker and scab.

Michelin.

Fruit : Size medium, often small. Shape conical cylindrical, often conical, sometimes pointed. Stem projecting considerably, rarely level with base ; thick and woody, often fleshy ; sometimes offset. Stem basin well defined ; shallow, sometimes deep ; medium width. Eye basin shallow or very slight ; not steep-sided ; eye puckered, distinct corona frequent. Calyx tightly closed, rarely slightly open. Sepals sometimes reflexed at tip ; often green at base ; some pubescence. Skin smooth, slightly waxy ; greenish-yellow, sometimes yellow. Flush sometimes present ; usually slight ; diffuse ; pink-orange ; sometimes confined to edge of russet round stem basin or to periphery of bruises. Russet on stem basin only, sometimes slightly spreading to cheek, sometimes small patch at eye. Lenticels often conspicuous ; medium size, regular, round. Scab : slightly susceptible. Tube narrow conical ; stamens slightly distal. Core slightly distal ; axile, loculi open ; loculi obovate with frequent pattern of cracks tending to be longitudinal. Seeds numerous ; if pollinators not present number may be very low ; dark brown. Flesh white ; slightly woolly ; sweet ; a little astringency usual. Harvest 4th week October onwards ; milling over period of more than 3 weeks.

Juice : Specific gravity 1.050 ; acidity 0.25 ; tannin 0.23.

Cider : Medium bittersweet ; generally similar to Bulmer's Norman, but softer tannin.

Flowering : Late mid-season ; diploid and a good pollinator.

Notes : Precocious, cropping good with slight biennial tendency. Tree of medium size with stiff, fairly upright limbs. A seedling raised by Monsieur

Legrand, a nurseryman of Yvetot. It first fruited in 1872 and was named after a Monsieur Michelin, who did much to promote the study of cider fruits. The variety was introduced into Herefordshire in 1884 when trees were brought to a Hereford nursery under the auspices of the Woolhope Naturalists Field Club. Extensive plantings have occurred in Herefordshire since 1927. Previously described by Hogg and Bull (4, 5).

Stoke Red.

Fruit : Size small, sometimes medium. Shape flattened spherical, rarely flattened conical. Stem variable ; within cavity or projecting slightly ; medium thickness. Stem basin slight or shallow. Eye basin well defined, shallow, sometimes deep ; sometimes steep-sided ; regular, smooth ; sometimes pubescent at base. Calyx closed. Sepals slightly reflexed at tips ; very pubescent. Skin smooth, slightly waxy, sometimes dry ; yellow or greenish-yellow. Flush always present ; usually more than two-thirds, frequently complete ; slight stripes, sometimes distinct ; dark red. Russet on stem basin only, occasionally spreading slightly to cheek ; often rough in stem basin. Lenticels usually inconspicuous, occasionally visible round stem basin. Scab : very resistant. Tube deep conical, sometimes funnel ; stamens pronounced distal ; styles very pubescent. Core median or slightly proximal ; axile, sometimes or always open ; loculi small obovate, sometimes round. Seeds numerous, fill cavities ; brown. Flesh white, sometimes slightly reddened ; soft ; very juicy, sharp ; usually with some astringency. Harvest 3rd week November onwards ; milling over period of more than 3 weeks.

Juice : Specific gravity 1.052 ; acidity 0.64 ; tannin 0.31.

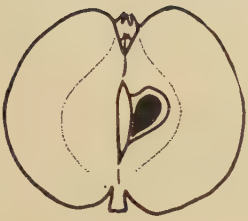
Cider : Bittersharp ; lacking in body ; often fruity ; slow fermenting juice.

Flowering : Late ; diploid and a good pollinator.

Notes : Delayed cropping, subsequently good with biennial tendency. Tree of medium to small size, compact, numerous small thick twiggy branches. Usually carries fruit right into centre of head. This variety came into prominence in the late 1920s, when records taken from trees growing at Rodney Stoke in Somerset showed that cropping was heavy and consistent. As no name was known, it was called Stoke Red. Subsequently older trees were found in the Wedmore area where it was known by the common name of Neverblight. It appears probable that the variety originated in this neighbourhood. Stoke Red has been recommended for planting where late flowering is an asset, though the small size of the fruit and the acidity of the juice may be regarded as drawbacks.

Sweet Coppin.

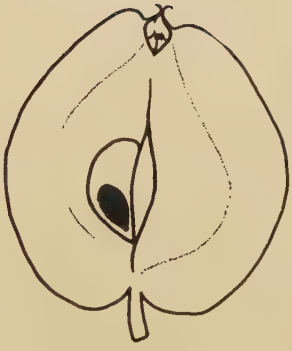
Fruit : medium, frequently large. Shape conical, frequently conical cylindrical, sometimes approaching flattened spherical. Stem usually projecting slightly ; medium thickness and woody. Stem basin slight ; wide and shallow. Eye basin well defined ; wide, usually shallow ; smooth. Calyx slightly open or open. Sepals narrow ; often free. Skin dry ; yellow or greenish-yellow. Flush usually present ; usually less than one-third ; diffuse, rarely flecked ; orange-pink, rarely dark red in flecks. Russet usually slight, spreading to cheek, frequently as net-like pattern, sometimes stem basin only. Lenticels



KINGSTON BLACK

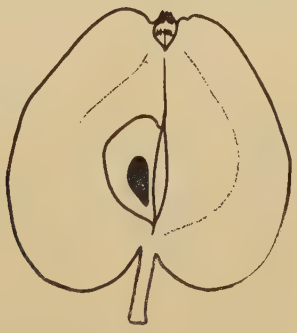
MICHELIN

SWEET COPPIN



TREMLETT'S BITTER

STOKE RED



YARLINGTON MILL

usually conspicuous, sometimes large and irregular, sometimes surrounded by small circle of dark red flush ; lenticel spot common. Scab : slightly susceptible. Tube conical ; stamens slightly distal. Core median ; abaxile, sometimes only open loculi ; loculi elliptical, sometimes obovate ; carpel wall sometimes patterned by cracks which are usually lateral. Seeds : number variable, often low for diploid variety ; brown. Flesh white, occasionally greenish ; soft ; sweet with no astringency. Harvest 4th week October—2nd week November ; milling over period of more than 3 weeks.

Juice : Specific gravity 1.052 ; acidity 0.20, tannin 0.14.

Cider : Pure sweet, occasionally very mild bittersweet.

Flowering : Mid-season ; diploid and a good pollinator.

Notes : Precocious, cropping very good biennial. Fruits rather variable because of a preponderance of king fruits, probably due to the advance flowering of the king blossoms. Origin in Devon.

Tremlett's Bitter.

Fruit : Size medium. Shape conical, tending to cylindrical ; round base ; pointed nose. Stem usually slightly projecting, sometimes level with base ; medium thickness, woody. Stem basin shallow, sometimes only slight ; narrow. Eye basin small, sometimes only slight ; shallow ; fairly steep-sided. Calyx usually tightly closed. Sepals rather long, reflexed at tips ; slightly pubescent. Skin smooth and waxy ; yellow, occasionally greenish-yellow. Flush always present ; always more than two-thirds ; usually flecked or slightly striped, rarely diffuse only. Russet on stem basin only ; very little, rarely none ; sometimes scaly. Lenticels conspicuous, occasionally inconspicuous ; usually small but surrounded by light patch ; occasional lenticel spot. Scab : fairly resistant. Tube conical, rarely funnel ; stamens median. Core slightly proximal ; usually axile, loculi open, rarely abaxile ; loculi elliptical or round, rarely obovate. Seeds numerous ; brown. Flesh usually white, occasionally yellow, rarely reddened below flush ; woolly ; sweet and astringent. Harvest 2nd—4th week October ; milling up to 3 weeks.

Juice : Specific gravity 1.052 ; acidity 0.27 ; tannin 0.34.

Cider : Full bittersweet ; hard and bitter tannin.

Flowering : Early ; diploid and a good pollinator, particularly for the early flowering triploids Court Royal and Bulmer's Norman ; self sterile.

Notes : Precocious, cropping very good, biennial. Origin in Devon.

Yarlington Mill.

Fruit : Size medium. Shape conical, sometimes approaching conical cylindrical ; flat base. Stalk slightly projecting, sometimes level with base ; medium thickness, woody. Stem basin wide ; deep, sometimes shallow. Eye basin rather small ; shallow, sometimes deep ; steep-sided ; always puckered. Calyx usually slightly open. Sepals short. Skin smooth, slightly waxy ; yellow or greenish-yellow. Flush usually covering two-thirds of cheek ; slightly striped or flecked with diffuse background, rarely distinctly striped or diffuse only ; dark red. Russet confined to stem basin, sometimes extending slightly to cheek ; often scaly. Lenticels inconspicuous. Scab : some susceptibility. Tube conical ; stamens very slightly distal. Core slightly proximal, axile, loculi sometimes open ; loculi obovate. Seeds numerous ; dark brown ;

elongated. Flesh white, frequently reddened beneath flushed skin ; slightly crisp ; sweet with some astringency usual. Harvest 4th week October—2nd week November ; milling over period of more than 3 weeks.

Juice : Specific gravity 1.052 ; acidity 0.22 ; tannin 0.32. The abnormally high value for tannin content is discussed on page 175.

Cider : Medium bittersweet.

Flowering : Early mid-season ; diploid and a good pollinator.

Notes : Precocious, cropping very good, biennial. One of the genuine Somerset Jersey cider apples. Probably of comparatively recent introduction, for there are few old trees to be seen. Its origin was undoubtedly in the village of Yarlington in the North Cadbury district of Somerset. It has proved very popular in south-east Somerset and is now widely planted throughout the West Country. There is some evidence to suggest that it needs a good soil if fruit and tree size are to be satisfactory. Yarlington Mill has been widely used in the West Midlands for head-working older and less productive varieties.

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(4) Hogg, R. and Bull, H. G. (1876–1885). *The Herefordshire Pomona.* Jakeman and Carver, Hereford.
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PERRY PEARS AND THEIR CHARACTERS : V.

By R. R. WILLIAMS and GILLIAN FAULKNER.

This article concludes a series in which 54 varieties of perry pear found in the West Midlands have been described. The present paper contains descriptions and illustrations of the final eight varieties of perry pear from Gloucestershire and Herefordshire. All the important varieties found in the West Midlands have now been described, and also the local varieties found in the main perry growing areas of Gloucestershire.

The figures given with each description contain drawings of typical fruits in longitudinal section, together with a flattened spur leaf. The typical winter appearance of mature trees is illustrated by photographs.

Clusters.

Fruit : 31–43 mm. long, 37–47 mm. diameter. Shape oblate, rarely turbinate. Stalk 11–22 mm. Stem basin absent or slight trace. Eye basin absent to slight. Calyx upright or reflexed. Sepals joined, often broken ; stamens attached at base of sepals. Skin pale green ; flush absent ; russet spreading ; lenticels conspicuous, small and brown ; scab usually present, trace only. Core has axial sac which is often partially filled ; seeds black. Flesh has prominent concentration of stone cells below eye and around core. Taste acid, astringent ; aroma only slight. Harvest 2nd–3rd week October. Milling period up to one week after harvesting. Cropping fairly good.

Tree : Medium to large. Fairly wide-angled crotches ; few main limbs with numerous large branches.

Flower : Flowering period mid-season. Flowers have short stalks ; petals separate and cupped, sepals slightly cupped or flat.

Leaf : Stalk 28–41 mm. Blade 48–56 mm. long, 36–41 mm. wide ; elliptical, tip acuminate or acute, base rounded, inclined to cordate ; serrations absent.

General notes : A variety found in the area immediately south of Gloucester. The strongly upheld, stiff, dull green leaves give a characteristic appearance.

Dead Boy.

Fruit : 37–49 mm. long, 36–50 mm. diameter. Shape turbinate. Stalk 13–27 mm., thick and fleshy, green ; large fleshy lips frequent. Stem basin absent, stem often merging with fruit. Eye basin absent or slight trace. Calyx upright, sometimes slightly reflexed. Sepals joined ; stamens attached at base of sepals. Skin yellowish green ; flush rare ; russet at stem and eye, very slight ; lenticels numerous, small ; scab absent. Core has well defined axial sac which is sometimes partially filled ; seeds black or brown. Flesh has heavy concentration of stone cells below eye and distinct ring of large stone cells around core. Taste juicy, fairly pronounced pear flavour, mildly acidic, no astringency ; slight aroma. Harvest 2nd–3rd week October. Milling 1–3 weeks after harvesting. Cropping very good, regular.

Tree : Large. Trunk may be continued as centre leader. Few heavy upright limbs ; numerous branches, many pendulous.

Flower : Flowering period mid-season. Flower buds have slight flush. King flowers often have additional petals.

Leaf : Stalk 36–53 mm. Blade 54–76 mm. long, 40–54 mm. wide : shape obovate, tip acute, inclined to acuminate, base rounded, inclined to cordate : serrations pronounced.

General notes : Variety rare : only found near Herefordshire border : one of the heaviest cropping varieties.

Ducksbarn.

SYN. DUCKSBOURNE, DUCKBARN.

Fruit : 44–55 mm. long, 35–45 mm. diameter. Shape turbinate or pyriform. Stalk 15–31 mm., sometimes thin. Stem basin absent, stem usually merging with fruit. Eye basin absent or absent to slight. Calyx upright : sepals joined, often broken : stamens attached at base of sepals. Skin greenish yellow : flush slight dappled with small green patches around lenticels ; russet slight, mainly at eye, spreading to cheek : lenticels small, inconspicuous : scab frequent. Core has axial sac which is large and well defined ; seeds black. Flesh has slight concentration of stone cells below eye and partial ring around core. Taste juicy, fairly pronounced pear flavour, mildly acidic, slightly astringent ; slight aroma. Harvest 1st 2nd week October. Milling period up to one week after harvesting. Cropping light.

Tree : Medium sized. Narrow-angled crotches. Small number of long limbs : numerous small branches, some of which are pendulous, giving a thin head.

Flower : Flowering period early mid-season. Flower buds pink. Petals touching, sepals slightly reflexed. Pollen production prolific.

Leaf : Stalk 24–37 mm. Blade 42–57 mm. long, 31–41 mm. wide : shape elliptical, inclined to ovate, tip variable, base rounded, inclined to cordate : serrations present.

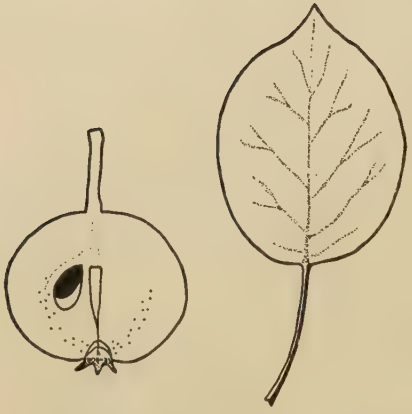
General notes : Scattered trees found in North Gloucestershire and the area immediately south of Gloucester. Tree has sparse foliage, leaves often brownish.

Early Griffin.

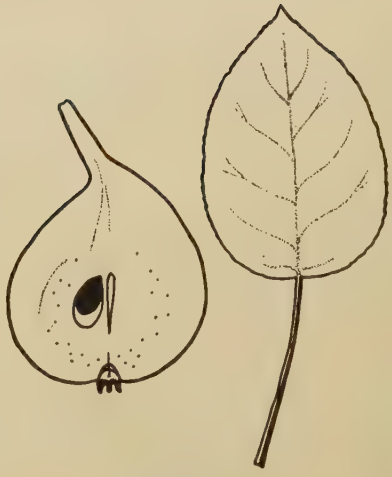
Fruit : 36–50 mm. long, 38–54 mm. diameter. Shape turbinate. Stalk 11–24 mm. long, stout with slight swelling at abscission point, green patches present. Stem basin absent. Eye basin slight, shallow. Calyx upright. Sepals free : stamens attached at base of sepals. Skin yellow ; flush absent : russet spreading to cheek ; lenticels very conspicuous, large and brown : scab rarely present. Core has large, well defined axial sac : seeds black. Flesh has fairly heavy concentration of stone cells below eye and around core. Taste juicy, pronounced pear flavour, mildly acidic, slight astringency : possesses an aroma. Harvest 2nd–3rd week September. Milling immediate. Cropping good, strongly biennial.

Tree : Large. Very narrow crotches : numerous tall limbs. Numerous heavy branches sometimes pendulous at tip due to crop.

Flower : Flowering period mid-season. Flower buds white. Flowers slightly cupped, with long reflex sepals.

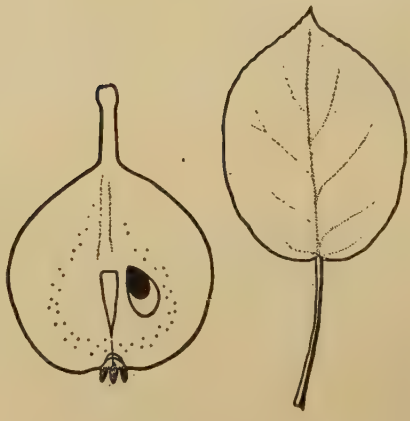


CLUSTERS



DEAD BOY

DUCKSBARN



EARLY GRIFFIN

PLATE V.

CLUSTERS

DEAD BOY

DUCKSBARN

EARLY GRIFFIN

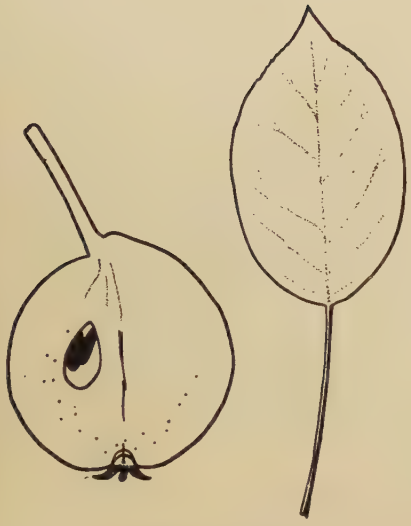
PLATE VI.

HELLENS EARLY

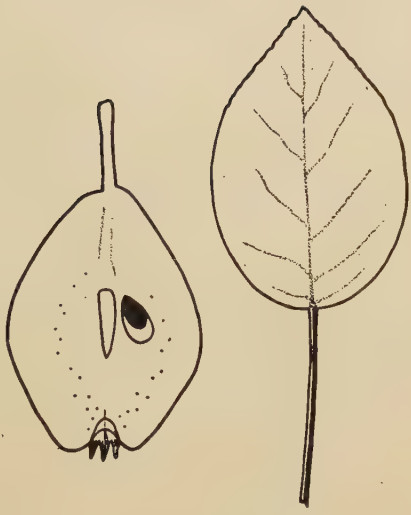
JENKINS' RED

LATE TREACLE

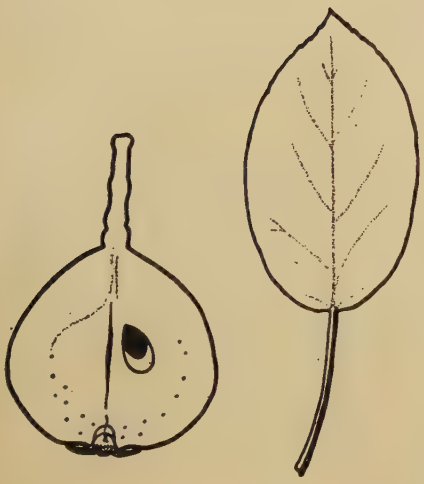
TEDDINGTON GREEN



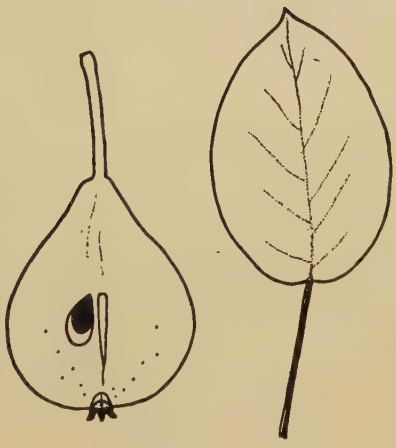
HELLENS EARLY



JENKINS' RED



LATE TREACLE



TEDDINGTON GREEN

Leaf : Stalk 18–34 mm. Blade 40–64 mm. long, 30–43 mm. wide ; shape elliptical, tip acute or acuminate, base cordate ; serrations slight.

General notes : A rare variety only found on the Herefordshire border. A possible alternative to Moorcroft as an early variety. Fruit characterized by very large lenticels.

Hellens Early.

SYN. SWEET HUFFCAP.

Fruit : 37–57 mm. long, 42–58 mm. diameter. Shape turbinate. Stalk 20–40 mm., usually connected to fruit by a fleshy lip, often partially green. Stem basin absent or absent to slight. Eye basin slight. Calyx variable, usually reflexed. Sepals variable, often joined ; stamens attached well below base of sepals. Skin greenish yellow ; flush slight to heavy ; russet at stem and eye, often spreading to cheek ; lenticels fairly conspicuous, small and brown ; scab sometimes present. Core has no axial sac ; seeds black. Flesh has concentration of stone cells below eye and a few around core. Taste juicy, pronounced pear flavour, mildly acidic, astringency slight to medium ; possesses a slight aroma. Harvest 2nd–3rd week September. Milling period up to one week after harvesting. Cropping very good.

Tree : Large. Wide-angled crotches ; few very tall limbs with numerous long, often pendulous branches. A very vigorous grower.

Flower : Flowering period mid-season. Flower buds have slight flush. Flowers large, with cupped petals and reflex sepals. Inflorescence pubescent. Germination poor.

Leaf : Stalk 37–63 mm. Blade 57–79 mm. long, 40–53 mm. wide ; shape ovate or elliptical, tip strongly acute, inclined to acuminate, base rounded, inclined to tapering ; serrations present, slight.

General notes : Rare ; found on the Herefordshire border and in West Gloucestershire. Selected for propagation by Radcliffe Cooke.

Jenkins' Red.

Fruit : 46–56 mm. long, 38–48 mm. diameter. Shape elliptical. Stem 13–23 mm., some green patches present. Stem basin absent or very slight. Eye basin well defined, deep. Calyx upright, sepals free, long ; stamens attached just below base of sepals. Skin greenish yellow ; flush heavy ; russet spreading to cheek ; lenticels conspicuous, brown ; scab absent. Core has axial sac which is usually well defined ; seeds black. Flesh has prominent concentration of stone cells below eye and a ring around core. Taste juicy, pronounced pear flavour, mildly acidic, astringency slight ; possesses an aroma. Harvest 1st–2nd week October. Milling immediately after harvesting. Cropping fairly good.

Tree : Medium to large. Characteristic bark divided into short segments. Narrow-angled crotches ; numerous upright limbs with pendulous branches.

Flower : Flowering period early mid-season. Flower buds white.

Leaf : Stalk 33–50 mm. Blade 43–69 mm. long, 36–43 mm. wide ; shape elliptical inclined to ovate, tip acute, base rounded ; serrations present.

General notes : Scattered trees found in North Gloucestershire. This variety is of interest as it is the only instance of elliptical fruits carrying a heavy flush.

Late Treacle.

Fruit : 32–38 mm. long, 34–40 mm. diameter. Shape turbinate. Stalk 17–27 mm., fleshy wrinkles. Stem basin absent. Eye basin slight. Calyx strongly reflexed. Sepals joined, long and whitish, often broken ; stamens attached just below sepals. Skin yellow or yellowish green ; flush usually heavy, orange red ; russet spreading from stem and eye ; lenticels conspicuous on flush ; scab sometimes present. Axial sac usually absent or small ; seeds black. Flesh has concentration of stone cells below eye and around core. Taste juicy, mildly acidic, slight astringency. Harvest 1st–2nd week September. Milling period up to one week after harvesting. Cropping sometimes heavy.

Tree : Medium ; wide-angled crotches, few very heavy limbs, small thick branches. Resembles small Tumper.

Flower : Flowering period mid-season. Flower buds pink. Flowers have short stalks ; petals widely separated, sepals flat.

Leaf : Stalk 22–31 mm. Blade 47–58 mm. long, 29–35 mm. wide ; shape elliptical, tip acute, base rounded; serrations present.

General notes : Scattered trees found in North and West Gloucestershire. One of the earliest harvesting perry pear varieties.

Teddington Green.

SYN. TEDDINGTONS.

Fruit : 41–62 mm. long, 38–53 mm. diameter. Shape pyriform. Stem 17–30 mm., green patches present. Stem basin absent or slight trace. Eye basin absent or absent to slight, often pubescent. Calyx upright, sepals often reflexed at tips ; sepals free or touching, pubescent, often broken ; stamens attached well below base of sepals. Skin yellowish green ; flush absent ; russet mainly around stem and eye ; lenticels conspicuous, small ; scab absent. Core has axial sac which is usually well defined ; seeds black or brown. Flesh has concentration of stone cells below eye and partial ring around core. Taste juicy, slight pear flavour, acid, astringent. Harvest 2nd–3rd week October. Milling period up to one week after harvesting. Cropping heavy, biennial.

Tree : Medium. Wide-angled crotches ; numerous heavy clean limbs, terminating in thick heavy branches.

Flower : Flowering season very late. Flower buds white. Flowers very pubescent; petals separate, very pale anthers.

Leaf : Stem 17–40 mm. Blade 50–67 mm. long, 37–47 mm. wide ; shape elliptical, tip acuminate or obtuse, base cordate ; serrations absent. Pubescent.

General notes : A variety common immediately north of Cheltenham. Tree resembles miniature Yellow Huffcap. It has a reputation for giving very heavy yields of fruit.

PERRY PEARS FOR PLANTING: II.

By R. R. WILLIAMS.

Introduction.

In 1956, at the request of the Cider Advisory Committee of the Research Station, a list of perry pears was presented for the guidance of those who wished to propagate or plant perry pears (1). Further information on the orchard behaviour and suitability of varieties for commercial perry production is now available, and it has been considered desirable to revise the list.

The past six years have seen the resumption of perry pear propagation on a considerable scale, and observations on the nursery performance of some 50,000 trees have been possible. Various propagation problems have been encountered, some of which are discussed below, for they have a considerable bearing on the choice of varieties.

The Revised List of Perry Pear Varieties.

The complete list now contains the following varieties : Barnet, Blakeney Red, Brandy, Brown Bess, Butt, Gin, Green Horse, Hellens Early, Hendre Huffcap, Judge Amphlett, Moorcroft, Newbridge, Oldfield, Parsonage, Red Longdon, Red Pear, Rock, Taynton Squash, Thorn, Winnal's Longdon, Yellow Huffcap.

It will be seen that five varieties have been omitted. *Arlingham Squash* has been found to be very susceptible to die-back, and cropping has been disappointing in view of its good reputation with growers in the past. The very intense astringency of *Flakey Bark* juice is not considered suitable for commercial perry. *Gregg's Pit* carried only light crops which in most years contained many cracked, scabby and small fruits. Little interest has been shown in *Chaceley Green* and *Turner's Barn* because of their small fruit size, and these varieties have not been propagated on a large scale.

Information summarized in Table 1 has been made available for the varieties *Taynton Squash*, *Parsonage* and *Green Horse* at the request of the manufacturers, who considered that the merit of their juices made them worthy of consideration despite some poor orchard characteristics. *Brown Bess* and *Newbridge* have been introduced because they have good orchard characters and produce a useful perry. *Hellens Early* has been included because observations suggest that it is superior in almost every way to the early harvesting varieties in the previous list.

Nursery Behaviour.

Information on propagation has been included because of the varied problems which have been encountered. In many instances the ease of propagation must be a deciding factor in determining a choice of varieties.

(a) *The selection of propagating material*

Shortly after the publication of the first list of perry pears for planting, the Research Station was asked whether it would provide propagating material to Members, as nothing was available from existing nurseries. For this purpose

TABLE I.

PERRY PEARS FOR PLANTING : ADDITIONAL VARIETIES.

Variety	Distribution	Harvesting	*Milling	Cropping	Fruit size	Tree size	Scab and canker	Perry	Notes
BROWN BESS	Common in a few parishes	2nd–4th week October	3 weeks	Very good	Very large	Medium to large	None	Sharp	Originally used as a culinary pear but capable of producing a good perry.
GREEN HORSE	Scattered ; infrequent	2nd–4th week October	3 weeks	Fairly good	Large	Large	Slight	Sharp	Included because of vintage quality.
HELLENS EARLY	Only a few trees remain	2nd–3rd week September	1 week	Very good	Medium	Large	Slight	Sharp	Considered a promising variety by Radcliffe Cooke but remained little known until recently. Probably the best early variety.
NEWBRIDGE	Only a few trees remain	1st–3rd week October	1 week	Good	Large	Very large	Little or none	Sweet	Probably a triploid. Regarded as an alternative to Moorcroft ; harvested a little later ; juice has lower tannin content.
PARSONAGE	Observations confined to a single tree	1st–2nd week October	1 week	Irregular	Medium	Large	Moderate	Bitter-sharp	Probably a triploid. Trees very susceptible to wind ; included because of superior vintage quality.
TAYNTON SQUASH	Uncommon	3rd–4th week September	2 days	Fairly good, usually biennial	Medium	Medium	Severe	Bitter-sharp	Included because of vintage quality.

* Time after harvesting.

a small number of mother trees of each variety was selected. These trees were the healthiest to be found and were all reputed to crop well ; many were over 100 years old, some over 200 years old.

The year following the first supplies of bud wood, all maiden trees on seedling pear stocks were examined several times during the growing season. It was seen that maiden trees often showed virus symptoms not apparent in the mature tree, while both sometimes carried latent infections, symptoms of which appeared where buds or grafts had failed to develop and the stock was allowed to grow out. Further selection of mother trees was then made to restrict propagation to material from the cleanest source of each variety.

In instances where the present trees represent only second or third generation, selection of mother trees has given considerable improvement, and propagating material free from pear mosaic, red mottle and pear blister canker has been obtained. Further search in existing orchards may provide sources of healthy material for other varieties of a similar age. Unfortunately the older varieties such as Red Pear and Green Horse, which are known to have been in existence for over 400 years, were uniformly infected, and provision of healthy material will depend on the success of heat therapy and related treatments.

(b) *Performance on seedling pear stocks*

Most of the perry pear trees being raised are on seedling stocks, and growth in the maiden year is very vigorous. In some varieties this growth is unable to support its weight and flops over, sometimes down to the ground. Though there is a superficial resemblance to rubbery wood in apple, the stems remain relatively brittle. This is similar to a condition found in Kaiser pear worked on Quince in Italy (2) and in Bristol Cross pear at Long Ashton (3) where it was shown to be graft-transmissible.

In most instances (e.g. Newbridge, Parsonage and Yellow Huffcap), the symptoms were severe only in the year following budding or grafting, but in a few varieties (e.g. Butt) there was little recovery in later years. The condition has been termed " floppy shoot " and a list of varieties of which no clean propagating material has yet been found is given in Table II.

Maiden trees of these varieties must be caned and tied at frequent intervals during the growing season, hence tree raising is expensive. Attempts to overcome the difficulty by using a stembuilder have not been successful. Several varieties which produce sturdy growth (e.g. Blakeney Red, Brandy, Pine and Thorn) have been tried, but in every case they produce very poor trees when headworked with a variety known to produce floppy growth. Until healthy propagating material is available it would seem wise to avoid the use of a stembuilder, thus giving the tree the opportunity to recover before any attempt is made to form a head. In varieties such as Butt, in which the condition persists, summer pruning of extension shoots materially helps to stiffen the young growth.

It has not been possible to find mother trees of some varieties free from symptoms resembling those of the virus disease " pear blister canker " described by Cropley (4) and recently shown by Wolkswinkel (5) to be caused by apple rubbery wood virus. Bark roughening and breakdown occur in the autumn of the maiden year with Blakeney Red and Red Pear ; second year

trees of Hendre Huffcap sometimes show transient symptoms, and a similar condition which occurs occasionally in Barnet trees is often lethal.

Information on vigour and the production of feather will be found in Table II. One variety, Gin, has been found to be very susceptible to magnesium

TABLE II.

NURSERY GROWTH OF MAIDEN PERRY PEARS.

Variety	*Growth*	*Feather*	*Vigour on seedling pear*	*Vigour on double-budded quince stocks*
Barnet	Fairly sturdy	None	Fairly strong	Very weak, rosetted
Blakeney Red	Sturdy	None	Strong	No growth, rosetted
Brandy	Sturdy	Some	Strong	
Brown Bess	Fairly sturdy	Some	Fairly strong	
Butt	Floppy	None	Fairly strong	Very weak, rosetted
Gin	Sturdy	None	Moderate	Weak
Green Horse	Sturdy	Some	Strong	Fairly strong
Hellens Early	Sturdy	Some	Strong	
Hendre Huffcap	Slightly floppy	Considerable	Strong	Strong
Judge Amphlett	Sturdy	None	Moderate	No growth, rosetted
Moorcroft	Slightly floppy and brittle	None	Fairly strong	Fairly strong
Newbridge	Floppy	Considerable	Strong	Strong
Oldfield	Slightly floppy	Some	Fairly strong	Strong
Parsonage	Floppy	Considerable	Strong	Strong
Red Longdon	Fairly sturdy	Some	Fairly strong	Fairly strong
Red Pear	Floppy	None	Weak	Very weak, rosetted
Rock	Slightly floppy	Some	Weak	Fairly strong
Taynton Squash	Fairly sturdy	Some	Moderate	Moderate
Thorn	Sturdy	Some	Fairly strong	Strong
Winnal's Longdon	Sturdy	None	Strong	Strong
Yellow Huffcap	Floppy	Some	Moderate	Fairly strong

deficiency, and nursery trees frequently failed to make a satisfactory height in the maiden year.

(c) *Performance on Quince A stocks*

There has been a need for precocious perry pear trees to produce fruit to supplement the diminishing supplies from the old West Midland orchards. Many trees have therefore been raised on clonal quince, though perry varieties are more difficult than dessert pears to grow on these rootstocks. In addition to the symptoms of virus type which appeared in trees worked on seedling pear, those on quince stocks showed features associated with incompatibility (6). These have been largely overcome by the use of an intermediate stock, either Beurré Hardy or the perry variety Rock. Unfortunately the use of an intermediate has not prevented rosetting (6) and this has continued to be a major problem. Both Blakeney Red and Judge Amphlett failed to make trees when worked directly on quince. Barnet, Butt and Red Pear rosetted initially but partially recovered later in the season to produce poor maidens (Table II). Double working, particularly double grafting, reduced the severity of the rosetting in each instance. It is still not possible, however, to raise a satisfactory tree of Blakeney Red or Judge Amphlett on quince.

Summary.

The list of perry pears for planting has been amended as the result of further experience gained during the past five years. Information on nursery behaviour, particularly reaction to some of the known pear viruses, is given, as this will often be a deciding factor in determining the choice of varieties for propagation.

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THE IDENTIFICATION OF THE PERRY PEARS OF GLOUCESTERSHIRE.

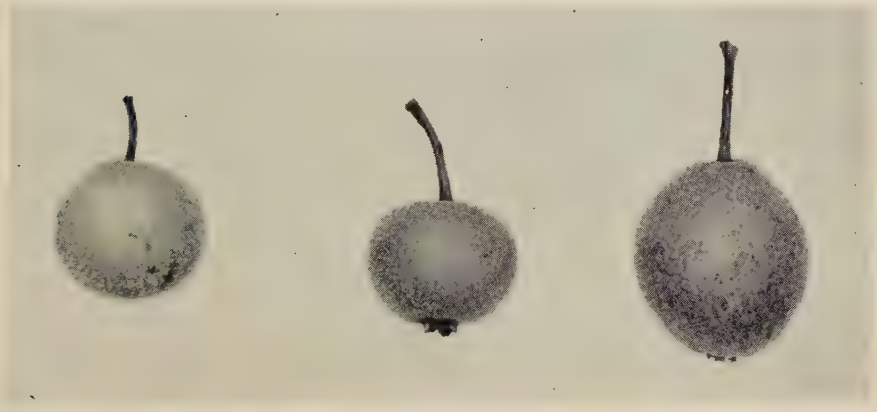
By R. R. WILLIAMS and GILLIAN FAULKNER.

The increased interest in the commercial production of perry has resulted in a demand for more knowledge concerning the varieties of perry pear in cultivation. The perry pears growing in Gloucestershire, the major producing county, have been surveyed (1, 2, 3) and all the important varieties have been described (4, 5, 6, 7, 8) ; from this information it has now been possible to work out a dichotomous key for their identification. Any variety not included in the key is of very restricted distribution and will only rarely be found on more than one farm. The key includes most varieties widespread in the orchards of the other West Midland counties. The preferred name of each variety is used, but a list of common synonyms will be found in the varietal notes appended to the key.

The primary division in the key is based on the date at which natural fruit fall is completed. In years when fruit maturity is particularly early or late, some allowance for this may have to be made, but the grouping of varieties at the beginning of each section should help. The terms used to indicate fruit characters are explained in Plates VII, VIII and IX. The key is intended for use in the field; the notes should provide an adequate check on identification.

Samples collected for identification should be of not less than 20 fruits, and should be collected when the fruit is falling freely. When assessing astringency care should be taken to avoid the skin or any flesh which has begun to break down. Fleshy stems often shrivel rapidly after abscission. Stems which are

1 2 3

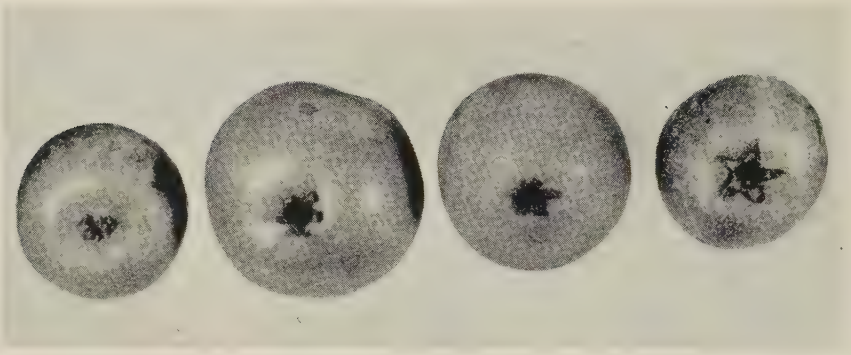


4 5 6

Fruit Shape. 1. Pyriform (Winnal's Longdon). 2. Acute turbinate (Pint). 3. Obtuse turbinate (Late Treacle). 4. Round (Holmer). 5. Oblate (Claret). 6. Elliptical (Yellow Huffcap).

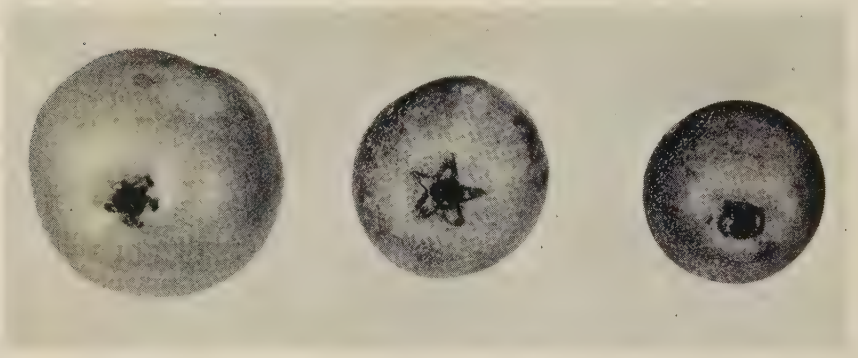
1 2 3 4

Lenticels. 1. Large and conspicuous (Blakeney Red). 2. Merging into patches (Thorn). 3. Small and distinct (Merrylegs). 4. Inconspicuous (Pine).



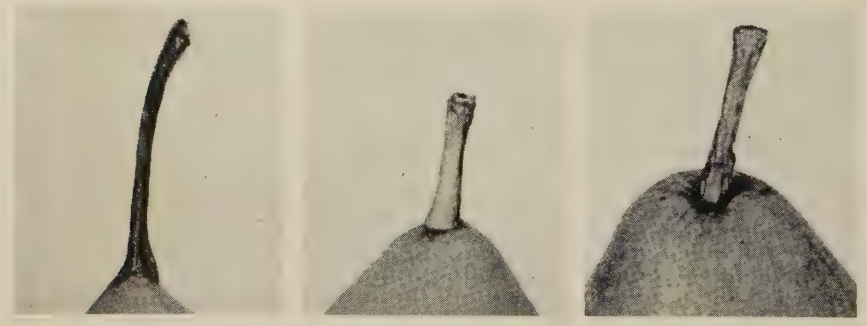
1 2 3 4

Calyx. 1. Closed (Rock). 2. Open, stiffly upright (Barnet). 3. Open, slightly reflex (Winnals Longdon). 4. Reflex, star shaped (High Pear).



1 2 3

Calyx. 1. Free sepals (Barnet). 2. Joined sepals (High Pear). 3. Tubular (Claret).



1 2 3

Stem Basin. 1. Merging (Ducksbarn). 2. Absent (Merrylegs). 3. Present (Red Longdon).

1

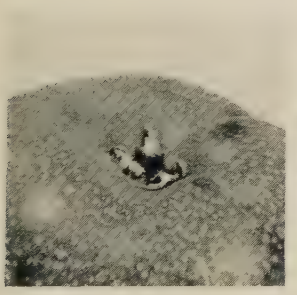
2

3

4

Stem

1. Knobbly
(Arlingham Squash)
2. Fleshy
(Late Treacle)
3. Fleshy lip
(Pint)
4. Green patches
(Parsonage)



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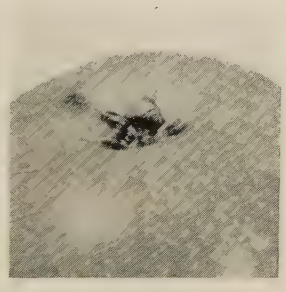

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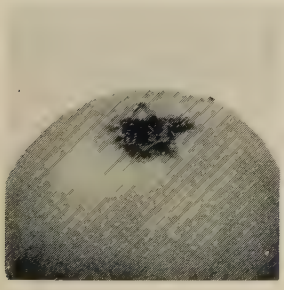

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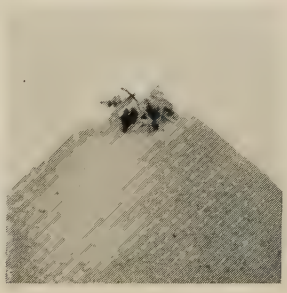

4

Eye Basin

1. Very distinct
(Rock)
2. Present
(Blakeney Red)
3. Absent
(Pine)
4. Raised eye
(Yellow Huffcap)

normally smooth may be malformed by scab : this causes slight bulges which must not be mistaken for knobbly stems. Sepals are often broken when the fruit hits the ground : those which are long and reflexed may thus be mistaken for short, upright sepals. Samples taken from young trees, or from mature trees in an " off " season, may be atypical, and allowance for increased fruit size and a change in season of fall should be made.

DICHOTOMOUS KEY TO PERRY PEARS OF GLOUCESTERSHIRE.

1	Fall complete before October ..	Section 1
	Fall complete in October	Section 2
	Fall complete after October ..	Section 3

Section 1—Fall complete before October.

(a)	*Always in September*	Early Griffin	Staunton Squash
		Hellens Early	Taynton Squash
		Knapper	Tumper
		Late Treacle	
(b)	*Sometimes in October*	Barland	Moorcroft
		Holmer	Thorn
		Judge Amphlett	
(c)	*Normally in October*	Arlingham Squash	White Longdon
		Barnet	

2	Russet complete, scaly ; tending to elliptical ; sepals free	**Barnet**
	Russet rarely complete ; if so turbinate, round or oblate	3
3	Stalks thick knobbly and fleshy	4
	Stalks not knobbly or fleshy	6
4	Sepals reflexed and distinctly star-shaped ; flush always present	**Late Treacle**
	Sepals not reflexed ; flush not always present	5
5	Lenticels prominent	**Early Griffin**
	Lenticels inconspicuous	**Arlingham Squash**
6	Most stalks with large patches of yellow or green	7
	Most stalks brown	9
7	Turbinate or inclined to oblate	**Hellens Early**
	Inclined to pyriform	8
8	Usually small ; ground colour yellow, flush frequent, lenticels inconspicuous	**Knapper**
	Usually medium to large ; ground colour green or yellowish green, flush absent ; lenticels prominent around eye	**Staunton Squash**
9	Sepals long and reflexed, calyx joined or tubular	10
	Sepals not long or reflexed	14
10	Inclined to pyriform	11
	Definitely turbinate or oblate	12
11	Many break down rapidly from core ; lenticels not usually conspicuous except sometimes around eye	**Staunton Squash**
	Keep more than ten days ; lenticels conspicuous	**White Longdon**
12	Stalks with large patches of yellow or green ; definitely turbinate	**Hellens Early**
	Stalks all brown ; inclined to round or oblate or definitely so	13
13	Prominent white lenticels	**Holmer**
	Lenticels not white	**Tumper**
14	Pyriform or many acute turbinates	15
	Many obtuse turbinates	19
15	Many break down rapidly from core green	**Staunton Squash**
	Do not break down rapidly from core until yellow	16
16	Eye raised	17
	Eye basin present though sometimes only slight	18

17 Pubescence usual on outer surface of sepals, extending to fruit .. .. .. **Thorn**
Pubescence usual on inner surface of sepals only, outer surface often green in unripe fruits .. .. **Judge Amphlett**
18 Russet often confined to eye or stem region; lenticels prominent .. .. **Moorcroft**
Russet often spreading, particularly from eye; lenticels tend to coalesce into patches of russet .. .. **Thorn**
19 Flush sometimes present .. .. **Taynton Squash**
Flush absent 20
20 Stalks stout, bulging at abscission point .. .. **Early Griffin**
Stalks not stout, not bulging at abscission point 21
21 Inclined to pyriform .. .. **Staunton Squash**
Turbinate or inclined to oblate 22
22 Many have well-defined patch of russet at base of stem .. .. .. **Barland**
Russet at base of stem often spreading and merging with background of cheek **Taynton Squash**

Section 2—Fall complete in October.

(a)	*Often in September*	Barland	Moorcroft
		Holmer	Thorn
		Judge Amphlett	
(b)	*Sometimes in September*	Arlingham Squash	White Longdon
		Barnet	
(c)	*Always in October*	Bartestree Squash	Newbridge
		Blakeney Red	New Meadow
		Brandy	Parsonage
		Clusters	Pine
		Coppy	Pint
		Deadboy	Red Longdon
		Ducksbarn	Red Pear
		Flakey Bark	Sack
		Green Horse	Teddington Green
		Green Longdon	Thurston's Red
		Gregg's Pit	Turner's Barn
		Hendre Huffcap	White Bache
		High Pear	Winnal's Longdon
		Jenkins' Red	Yellow Huffcap
		Merrylegs	
(d)	*Normally in November*	Brown Bess	Gin
		Claret	Oldfield

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23 Pyriform 24
Turbinate round or oblate 50
Elliptical 109
24 Flush absent 25
Flush present 35
25 Calyx always reflexed, large and conspicuously star-shaped 26
Calyx usually upright, not conspicuously reflexed 28
26 Palatable, sweet, slight astringency sometimes present; yellow in early October **Newbridge**
Unpalatable, acidic and astringent; not yellow in early October 27
27 Calyx reflexed but not flat, because of deep eye basin .. **White Longdon**
Calyx reflexed, often flat, eye basin wide and shallow .. .. **Flakey Bark**
28 Some become yellow during September 16
Never yellow during September 29
29 Stalks long and thin with patches of green .. .. **Parsonage**
Stalks rarely long and thin, always brown 30
30 Eye basin absent 31
Eye basin present 33

31 Eye usually raised ; yellow when ripe .. .. **Judge Amphlett**
Eye rarely raised ; not yellow when ripe 32
32 High acid, low astringency .. .. **Pint**
High acid, high astringency .. .. **Teddington Green**
Low acid, high astringency ; very gritty flesh .. .. **Flakey Bark**
33 Definitely pyriform ; russet often confined to stem and eye region ; very resistant to scab .. .. **Teddington Green**
Inclined to turbinate or irregular ; russet usually spreading ; susceptible to scab 34
34 Russet virtually complete ; large white conspicuous lenticels ; astringency low **New Meadow**
Russet usually not more than spreading ; lenticels rarely white ; astringency high 27
35 Lenticels flushed red .. .. **Thurston's Red**
Lenticels never red 36
36 Flush red, often heavy 37
Flush often orange, only slight 47
37 Stem basin absent 38
Stem basin present 44
38 Stem woody 39
Stem fleshy 42
39 Filaments often red ; distinctly pyriform ; frequent bloom on flush **Winnal's Longdon**
Filaments black ; inclined to turbinate ; no bloom on flush 40
40 Distinct corona round eye of most fruits .. .. **Merrylegs**
Distinct corona rare 41
41 Flush dull brownish-red, often blotchy ; merging stems absent ; lenticels large corky, present on whole fruit .. .. **Green Longdon**
Flush orange red ; merging stems frequent ; lenticels small, surrounded by small green areas on flush .. .. **Ducksbarn**
42 Stems short and thick, less than half inch .. .. **Brandy**
Stems medium to long, more than half inch 43
43 Breaks down rapidly from core in early October .. .. **Gregg's Pit**
Does not break down rapidly in early October .. .. **Ducksbarn**
44 Filaments often red ; distinctly pyriform ; bloom on flush frequent **Winnal's Longdon**
Filaments black, inclined to turbinate ; no bloom on flush 45
45 Flush usually slight ; yellow when mature .. .. **White Longdon**
Flush usually heavy, sometimes blotchy ; green 46
46 Cavity of eye open ; calyx usually reflexed ; eye basin wide and shallow ; flush often bright red .. .. **Red Longdon**
Cavity of eye usually closed ; calyx only slightly open ; eye basin deep and steep ; flush dull brownish-red and blotchy .. .. **Green Longdon**
47 Some yellow by first week October 17
None completely yellow by first week October 48
48 Stems fleshy ; breakdown from core rapid .. .. **Gregg's Pit**
Stem woody ; does not break down immediately on falling 49
49 Stem basin absent, merging stems frequent .. .. **Ducksbarn**
Stem basin sometimes present ; merging stems rare 34
50 Flush present 51
Flush absent 91
51 Round or oblate 52
Turbinate 59
52 Stem often merging ; green colour extending up stem .. .. .. **High Pear**
Stem rarely merging ; brown 53
53 Stem exceeds fruit in length 54
Stem less than fruit in length 56
54 Calyx closed or only slightly open ; eye basin often puckered .. .. .. **Gin**
Calyx open or reflexed 55
55 Stem basin always present ; definitely round or oblate ; heavy pubescence on sepals, sometimes spreading to surface of fruit .. .. .. **Turner's Barn**
Stem basin absent or slight ; inclined to turbinate ; sepals sometimes pubescent **Sack**
56 Flush heavy, bright red .. .. **Red Pear**
Flush only slight, often yellowish 57
57 Stem knobbly, often swollen at abscission point .. .. .. **Arlingham Squash**
Stem not knobbly 58
58 Calyx distinctly star-shaped ; small .. .. **Holmer**
Calyx not star-shaped ; large .. .. **Green Horse**
59 Lenticels small and red .. .. **Thurston's Red**
Lenticels not red 60
60 Flush light, often orange 61
Flush heavy, red 76

61 Calyx reflexed and star-shaped 62
Calyx upright or only slightly reflexed 65
62 Stem basin present ; stems brown 63
Stem basin absent, merging stems present ; green patches on stem 64
63 Stem length exceeding half fruit length, often swelling near junction with fruit **Blakeney Red**
Stem length not exceeding half fruit length, no swelling near junction with fruit .. 27
64 Softens quickly on falling .. .. **High Pear**
Remains firm for two to three weeks after falling .. .. **Pine**
65 Stem exceeds fruit in length 66
Stem less than fruit in length 67
66 Calyx closed or slightly open .. .. **Gin**
Calyx open or reflexed .. .. **Sack**
67 Yellow before October .. .. **Thorn**
Not yellow before October 68
68 Stem exceeds half fruit length 69
Stem never exceeds half fruit length 70
69 Lenticels white, very conspicuous ; medium to small ; russet dark brown **New Meadow**
Lenticels often brown, distinct except around stem and eye ; medium to large ; russet golden brown .. .. **Blakeney Red**
Lenticels small, inconspicuous except on flush, where each lenticel is set in a small green patch ; medium to small ; russet slight, indistinct, mainly around eye **Ducksbarn**
70 Stem fleshy 71
Stem woody 73
71 Stem often exceeds half fruit length .. .. **Sack**
Stem less than half fruit length 72
72 Calyx tubular .. .. **Arlingham Squash**
Calyx never tubular, sepals usually free .. .. **Gregg's Pit**
73 Russet confined to eye and stem region, rarely spreading over cheek ; bright yellowish green .. .. **Green Horse**
Russet usually spreading, may be almost complete 74
74 Low acidity, low astringency 75
Variable acidity, high astringency 27
75 Lenticels large white, conspicuous .. .. **New Meadow**
Lenticels not all large white or conspicuous ; russet often scaly .. .. .. **Barnet**
76 Astringent, often acidic 77
No astringency, very low acidity 85
77 Merging stems rare, stem basin sometimes present 78
Merging stems, stem basin absent 83
78 Obtuse turbinate, tending to round 79
Acute turbinate, tending to pyriform 82
79 Stalk exceeds fruit in length ; medium to small 66
Stalk usually less than fruit in length ; medium to large 80
80 Greenish, flush dull red .. .. **Bartestree Squash**
Yellow or yellowish green, flush bright red 81
81 Eye basin deep and smooth .. .. **Blakeney Red**
Eye basin absent to slight, puckered .. .. **Red Pear**
82 Stem long, often exceeding half fruit length, often swelling at junction with fruit **Blakeney Red**
Stem length never exceeds half fruit length 45
83 Corona present around eye .. .. **Merrylegs**
Corona usually absent 84
84 Obtuse turbinate, inclined to oblate .. .. **Sack**
Acute turbinate, inclined to pyriform 43
85 Stem short and thick, less than half inch 86
Stem medium length, more than half inch 87
86 Inclined to pyriform ; large fleshy lip frequent ; stalks misplaced to one side common .. .. **Brandy**
Inclined to round ; large fleshy lip rare .. .. **Red Pear**
87 Distinct corona around eye .. .. **Merrylegs**
Corona absent, though puckering possible 88
88 Stem long, often exceeding half length of fruit .. .. .. **Blakeney Red**
Stem not exceeding half length of fruit 89
89 Calyx stiff upright, often clawed ; russet scaly .. .. **Barnet**
Calyx usually reflexed, never clawed 90
90 Obtuse turbinate tending to round ; yellow when ripe .. .. .. **Red Pear**
Acute turbinate tending to pyriform ; green .. .. **Red Longdon**

91 Some become yellow in September 92
None yellow in September 93
92 White lenticels ; small ; round or oblate .. .. **Holmer**
Lenticels not white ; medium to large ; turbinate or inclined to pyriform .. 18
93 Calyx strongly reflexed, conspicuously star-shaped 94
Calyx not strongly reflexed, not conspicuously star-shaped 96
94 Green patches on stem ; merging stems frequent 64
Stem usually brown only, merging stems rare 95
95 Obtuse turbinate, inclined to oblate ; medium to small .. .. .. **Clusters**
Often acute turbinate ; inclined to pyriform ; medium to large 26
96 Oblate ; small ; russet complete .. .. **Claret**
Not oblate and small 97
97 Stem knobbly, often large swelling at abscission point ; calyx tubular **Arlingham Squash**
Stem not knobbly, no large swellings at abscission point ; calyx rarely tubular .. 98
98 Russet usually complete ; astringency absent or very slight 99
Russet rarely complete ; astringency present 100
Russet rarely complete ; astringency low, acidity high .. .. **Pint**
99 Acidity high unless ripe ; large .. .. **Brown Bess**
Acidity low ; medium to small 75
100 Small distinct stem basin ; small deep eye basin .. .. .. **White Longdon**
Stem basin and eye basin not present in all specimens 101
101 Stem fleshy 102
Stem woody 104
102 Green patches on stem frequent ; keeps to late October .. .. .. **Deadboy**
Stem brown ; breaks down before late October 103
103 Lenticels large, light coloured around stem, small around eye .. .. **White Bache**
Lenticels small over whole fruit .. .. **Gregg's Pit**
104 Lenticels inconspicuous, small not russeted .. .. **Pine**
Lenticels conspicuous, usually russeted 105
105 Acute turbinate, inclined to pyriform .. .. **Flakey Bark**
Obtuse turbinate, inclined to round or oblate 106
106 Stem often equal to fruit in length ; sepals often projecting 107
Stem rarely equal to fruit in length ; sepals often flattened 108
107 Russet usually heavier at stem than eye ; axial sac well defined ; breakdown from core within a week ; merging stems infrequent .. .. **Barland**
Rarely more russet at stem than eye ; axial sac not well defined ; keeps for several weeks ; merging stems frequent .. .. **Oldfield**
108 Eye basin smooth ; large ; russet confined to stem and eye .. .. .. **Green Horse**
Eye basin puckered ; medium to small ; russet spreading to cheek .. **White Bache**
109 Flush present 110
Flush absent 113
110 Inclined to turbinate or round ; russet heavy scaly, usually complete ; lacks astringency .. .. **Barnet**
Elliptical or very acute turbinate ; russet not heavy or scaly, rarely complete ; some astringency 111
111 Eye basin present .. .. **Jenkins' Red**
Eye basin absent, eye sometimes raised 112
112 Calyx upright or slightly reflexed, sepals free, sometimes touching ; scab rare ; stem basin absent, stem usually raised .. .. **Hendre Huffcap**
Calyx upright or slightly closed, sepals usually touching, sometimes joined ; scab frequent ; stem basin sometimes present, stem occasionally raised .. .. **Coppy**
113 Stem basin usually absent 112
Stem basin usually present 114
114 Predominantly greenish yellow ; indistinct russet, sometimes confined to eye and stem ; scab frequent .. .. **Coppy**
Predominantly brown ; heavy russet spreading to cheek ; scab rare **Yellow Huffcap**

Section 3—Harvested in November or Later.

(a)	*Sometimes in October*	Brown Bess	Gin
		Claret	Oldfield
(b)	*Normally in November or later*	Butt	Nailer
		Lumber	Rock

115 Pyriform 116
Turbinate, round or oblate 117

116	Large ; dull red flush ; lenticels large, russeted and conspicuous	**Lumber**
	Medium size ; bright orange flush ; lenticels small not conspicuous	**Nailer**
117	Russet virtually complete	118
	Russet rarely complete	120
118	Medium to large ; little or no astringency	**Brown Bess**
	Medium to small ; astringent	119
119	Sepals tubular ; eye basin slight	**Claret**
	Sepals not tubular ; eye basin deep	**Rock**
120	Green patches on stem	**Butt**
	Stems brown	121
121	Deep stem and eye basin	**Rock**
	Stem and eye basin absent or slight	122
122	Calyx closed ; corona present	**Gin**
	Calyx upright ; corona absent	123
123	Lenticels inconspicuous ; red flush	**Nailer**
	Lenticels conspicuous ; flush rare, yellow	**Oldfield**

Notes on Varieties.

Arlingham Squash *Syn.* Squash Pear, Old Squash — Common in the south-west, particularly near Severn, scattered trees elsewhere. Medium to small ; wide-angled crotches ; long slender upright limbs. Thin open branches usually dying back with canker, numerous young shoots. Fruits fall over a long period (6).

Barland — Common. Large ; wide-angled crotches ; trunk usually continued as a few large upright limbs ; tall head ; small branches. Fruit fall over a long period. Fruits of Oldfield or Early Griffin may be confused with this variety (4).

Barnet *Syn.* Barn Pear, Brown Thorn — Common immediately south of Gloucester, in Long Ashton trial orchards throughout county. Medium to large ; narrow-angled crotches ; numerous long branches with spreading habit due to crop ; conspicuous spurs consisting largely of bourse shoots (4).

Bartestree Squash — Rare, near Herefordshire border. Large ; trunk continued as centre leader ; few limbs ; numerous small, very twiggy branches. Fruits fall over a long period. Fruits of Green Longdon may be confused with this variety (6).

Blakeney Red *Syn.* Circus Pear, Painted Lady. — Very common in west and south-west, uncommon elsewhere. Widely planted in latter part of last century as dual-purpose pear. Medium to large ; very narrow-angled crotches ; the numerous upright limbs fuse in crotch. Fruits of Red Longdon, Ducksbarn and Nailer may be confused with this variety (4).

Brandy — Uncommon, confined to west. Medium to small ; wide-angled crotches ; limbs spreading due to crop ; branches stout. Fruits of Red Pear may be confused with this variety (6).

Brown Bess *Syn.* Brown Bessie. — Scattered, in south-west. Originally used for culinary purposes. Medium to large ; narrow-angled crotches ; usually several upright limbs ; numerous branches, horizontal or pendulous due to crop (7).

Butt *Syn.* Norton Butt. — Common. Medium to large ; narrow-angled crotches ; limbs spreading due to crop ; heavy conspicuous spur systems. Fruits often keep on ground into following year. Fruits of Oldfield may be confused with this variety (4).

Claret — Only in Long Ashton trial orchards. Large ; wide-angled crotches ; numerous large limbs spreading due to crop ; numerous branches of rather thick growth (6).

Clusters — Scattered, immediately south of Gloucester. Large ; wide-angled crotches ; numerous limbs ; large branches ending in dense twiggy growth (8).

Coppy *Syn.* Coppice. — Uncommon, in west. Large ; trunk usually continued as centre leader ; narrow-angled crotches ; small number of upright limbs ; numerous branches with dense, very thin, twiggy growth. Fruits of Hendre Huffcap may be confused with this variety (6).

Deadboy — Rare, near Herefordshire border. Large ; trunk may be continued as centre leader ; few heavy upright limbs ; numerous branches, many pendulous (8).

Ducksbarn *Syn.* Duckbarn, Ducksborne. — Fairly common in north, scattered immediately south of Gloucester. Medium ; narrow-angled crotches ; long limbs terminating in small thin branches, some pendulous (8).

Early Griffin — Rare, near Herefordshire border. Large ; very narrow crotches ; numerous tall limbs ; numerous heavy branches, sometimes pendulous at tip due to crop (8).

Flakey Bark .. .. Rare, confined to west. Medium to large; wide-angled crotches; straggling limbs; bark on main limbs flakes off giving characteristic off-white patches; thick twiggy branches. Fruits of White Longdon may be confused with this variety (7).

Gin .. .. .. Common in Newent district. Medium size; narrow-angled crotches; limbs slightly spreading due to crop; heavy conspicuous spur systems. Fruits of Nailer may be confused with this variety (5).

Green Horse .. .. Scattered, in north and north-west. Large; narrow-angled crotches; numerous large heavy upright limbs terminating in small stiff branches (6).
Syn. Horse Pear.

Green Longdon .. .. Common in west. Medium size; trunk usually continued as centre leader to a considerable height; wide-angled crotches; small branches, numerous spurs. Fruits of Bartestree Squash, Lumber and Red Longdon may be confused with this variety (5).
Syn. Old Fashioned Longdon, Brown Longdon, Russet Longdon.

Gregg's Pit .. .. Common near Herefordshire border. Large; narrow-angled crotches; usually a small number of large, long, upright limbs; small lateral branches. Fruits of White Bache and Staunton Squash may be confused with this variety (7).

Hellens Early .. .. Rare, near Herefordshire border. Large; wide-angled crotches; few very tall limbs; numerous, long, often pendulous branches, very vigorous growth (8).

Hendre Huffcap .. .. Common around Haresfield. Large; wide-angled crotches; small number of long upright limbs; branches pendulous with numerous spurs. Fruits of Coppy may be confused with this variety (5).
Syn. Yellow Huffcap, Huffcap.

High Pear .. .. Uncommon, confined to north-west. Medium size; trunk usually continued as centre leader; narrow-angled crotches; small number of upright limbs; numerous branches with dense, very thin, twiggy growth (6).

Holmer .. .. .. Uncommon, confined to north west. Widely planted about 1800 on recommendation of T. A. Knight. Large; narrow-angled crotches; very tall limbs; numerous branches forming a dense head (5).
Syn. Cluster Top, Startlecock.

Jenkins' Red .. .. Fairly common around Cheltenham. Medium to large; characteristic bark, divided into short segments; narrow-angled crotches; numerous upright limbs with pendulous branches. Fruits of Red Pear may be confused with this variety (8).

Judge Amphlett .. .. A Worcestershire variety, only in Long Ashton trial orchards. Medium size; trunk usually continued as centre leader; narrow-angled crotches; few limbs; numerous branches of dense twiggy growth (6).

Knapper .. .. .. Common in west and north-west. Large; narrow-angled crotches; numerous very tall limbs terminating in small branches forming a wide flat head. One of the earliest perry pears to be harvested (5).

Late Treacle .. .. Scattered, particularly in west. Medium size; wide-angled crotches; few very heavy limbs; small thick branches (8).

Lumber .. .. .. Common in west. Probably planted for culinary purposes, a very large and attractive fruit of little value. Small; sparse limb system; numerous, often pendulous branches (6).
Syn. Lumber Red, Steelyard Balls

Merrylegs .. .. Scattered in west. Medium to small; narrow-angled crotches; numerous long spreading limbs terminating in small, thick twiggy branches. Fruits of Red Pear may be confused with this variety (7).

Moorcroft .. .. Common. Large; narrow-angled crotches; small number of long upright or slightly spreading limbs; small brittle branches. Fruits of Thorn and Newbridge may be confused with this variety (4).
Syn. Malvern Hills.

Nailer .. .. .. Common in vicinity of Newent. Small; trunk usually continued as centre leader; narrow-angled crotches; few large limbs; numerous branches of twiggy growth. Fruit of Ducksbarn may be indistinguishable from this variety except by keeping quality (7).
Syn. Billy Williams

Newbridge .. .. Scattered throughout north-west, common in slopes of Malverns. Large; wide-angled crotches; several very large upright limbs with characteristic bends where upright growth recommences; branches sparse and brittle; extension shoots usually curled, often pendulous. Late fruits of Moorcroft may be mistaken for this variety (7).
Syn. White Moorcroft.

New Meadow .. .. Common in areas adjoining Worcestershire border. Medium to large; wide-angled crotches; small number of large straggling limbs; usually thin sparse branches (5).

Oldfield .. .. .. Common. Medium to small; wide-angled crotches; old trees often consist of only a few small branches because of severity of die-back. Fruits of Barland and Clusters may be confused with this variety (4).
Syn. Olleville.

Parsonage . . . . Scattered, in north-west. Large ; wide-angled crotches ; numerous large limbs giving a wide framework ; branches often pendulous ; die-back severe but extension growth very strong, usually curled, often pendulous. Usually appears windswept (7).

Pine . . . . . Only in Long Ashton trial orchards. Small ; narrow-angled crotches ; numerous stiff upright limbs opening a little due to crop ; complex spur system very prominent. Die back often severe. Fruits of High Pear may be confused with this variety (4).

Pint . . . . . Scattered in north-west. Large ; narrow-angled crotches ; numerous sturdy upright limbs ; numerous twiggy, often pendulous branches. Fruits of Teddington Green may be confused with this variety (6).
Syn. Pine

Red Longdon . . . . Common. Medium to large ; narrow-angled crotches ; long upright limbs ; small branches tapering quickly to twiggy growth. Die-back usually severe, resulting in a thin head. Fruits of Blakeney Red may be confused with this variety.

Red Pear . . . . Common in west with scattered trees in north. Medium to small ; trunk often continued as centre leader ; small branches with thick spurs. If leader bifurcates, splitting down the crotch is very probable. Fruits of Brandy and Red Longdon may be confused with this variety (4).
Syn. Red Horse, Alyton Red, Blunt Red.

Rock . . . . . Scattered trees in north and north-west. Medium size ; very wide-angled crotches ; bark deeply striated longitudinally ; large horizontal limbs common ; branches with thin twiggy wood, often severe die back (4).
Syn. Brown or Black Huffcap, Mad Pear.

Sack . . . . . Common around Newent. Medium to large ; sturdy upright limb system ; numerous branches with characteristic very wide-angled crotches ; thick growth of twigs giving a dense head. Leaves turn brown and fall with fruit (5).

Staunton Squash . . Scattered immediately south of Malverns. Large ; small number of large limbs ; numerous branches with twiggy, often pendulous growth, prominent spur often present. The only early maturing pear to break down while green. Fruits of White Bache and Gregg's Pit may be confused with this variety (7).

Taynton Squash . . Only in Long Ashton trial orchards. Medium to large ; wide-angled crotches, small number of large, sometimes straggling limbs ; numerous branches terminating in twiggy growth. Fruits of Hellens Early and Early Griffin may be mistaken for this variety (4).

Teddington Green . . Common immediately north of Cheltenham. Medium size ; wide-angled crotches, numerous heavy, clean limbs terminating in thick heavy branches. Resembles miniature Yellow Huffcap tree. Fruit of Pint may be confused with this variety (8).

Thorn . . . . . Common in north-west, scattered elsewhere. Small, narrow-angled crotches ; stout limbs and branches of stiff upright habit ; conspicuous spurs. Fruits of Moorcroft and Judge Amphlett may be confused with this variety (5).

Thurston's Red . . . . Scattered in west. Medium size ; trunk continued as centre leader ; wide-angled crotches ; small number of large straggling branches. Very characteristic bark, divided in square blocks by deep cracks (6).

Tumper . . . . . Scattered in west. Large ; wide-angled crotches ; numerous limbs giving a large wide framework ; numerous branches with heavy spur systems (6).

Turner's Barn . . . . Common around Newent, scattered elsewhere. Medium size ; narrow angled crotches ; numerous upright limbs of common origin ; branches fairly stout but twiggy, giving dense head (5).
Syn. Longstalk.

White Bache . . . . Scattered in north-west. Large ; wide angled crotches ; spreading, frequently horizontal, limbs ; dense twiggy branches. Fruit in any year usually confined to few branches, a prominent characteristic as fruit is a conspicuous light green. Fruits of Gregg's Pit may be confused with this variety (5).

White Longdon . . Scattered, also in Long Ashton trial orchards under the name Port. Large ; trunk usually continued as centre leader to a considerable height ; branches often pendulous with numerous young upright shoots. Fruits of Flakey Bark may be confused with this variety (5).
Syn. Dandoes, Garradine.

Winnal's Longdon . . Fairly common near Herefordshire border. Medium to large ; sturdy upright limb system with numerous small branches giving a compact tree (4).

Yellow Huffcap . . . . Scattered. Large ; large spreading clean limbs ; numerous small twiggy branches with small spurs. Fruit must be shaken before it is ripe or it may rot on tree (4).
Syn. Brown Huffcap, Huffcap.

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SPRAY APPLICATION PROBLEMS: LXVII. THE DISTRIBUTION OF MERCURY IN PLANT TISSUES AFTER LEAF APPLICATIONS OF PHENYLMERCURIC ACETATE.

By J. A. PICKARD and J. T. MARTIN.

Work was continued in 1961 on the movement of mercury in plants and on the degree of contamination of apple fruits after treatment with phenylmercuric acetate. In 1958, an examination of deposits on coffee leaves (1) indicated the possibility of the translocation of mercury from sprayed foliage to newly emerging leaves. In 1959, work was carried out (2) on the uptake of mercury by plants from nutrient solution and soil containing phenylmercuric acetate, on the degree of contamination of the roots and tops of plants grown in soils treated with inorganic mercury compounds, and on the penetration of mercury, applied as phenylmercuric acetate, into apple leaves and fruits. The possibility put forward that the mercury found in the flesh of apple fruits gained access by translocation from the leaves was confirmed in 1960 (3), supporting the conclusion of Ross and Stewart (4, 5) in Canada.

The general picture built up from these results was that, when applied in water-soluble form (phenylmercuric acetate or mercuric chloride), mercury was absorbed by leaves and roots, that it tended to be held by the fibrous tissues of plants, and that translocation occurred more readily from leaves than roots. Further work, now reported, was carried out in 1961 on the movement of mercury from leaves, using the broad bean and potato plants. In the 1960 work on apples, an abnormally high contamination of fruits was found following efficient hand-spraying, to run-off, with a proprietary phenylmercuric acetate wash to which a wetter was added. In 1961 the tests were therefore repeated to determine the effect of the wetter and of increasing the number of applications.

Experimental.

Analysis

Analyses were made by the dithizone method already described (6). Acid digestion of the plant material was carefully controlled to prevent loss of mercury, and interference from other metals was reduced to a low level by the use of ethylenediaminetetra-acetic acid (disodium salt). The method was capable of detecting 1 μg. Hg in 50 g. of plant material.

The movement of mercury from leaves

(a) *Broad bean.* Tests were made in 1960 and 1961 on plants raised in pots in the glasshouse. The plants were sprayed in mid-May, at an early stage of flower development, with a proprietary phenylmercuric acetate wash (0·005 per cent Hg) containing an added 1 ml. of Ethylan C.P. wetter per gallon. The surface of the soil was protected from the spray by a polythene sheet. In mid-July, when the pods had matured, the parts of whole plants were weighed and analysed for mercury; the roots of the plants were well washed before the

tests to avoid possible surface contamination from the soil. The results, corrected for control values, are given in Table I as parts per million.

TABLE I.

DISTRIBUTION OF MERCURY IN BROAD BEAN PLANTS.

	1960		*1961*	
	Fresh wt. (g.)	Hg (p.p.m.)	Fresh wt. (g.)	Hg (p.p.m.)
Leaf laminae ..	65	1·32	33	2·14
Leaf petioles ..	13	0·49	5	0·49
Stems	47	0·32	36	0·44
Pods	182	0·01	130	0·02
Seeds	70	0·04	100	0·03
Roots	84	0·07	23	0·06

The seeds contained small amounts of mercury which could have gained access only by internal movement into them during their growth. The results for the roots similarly suggested translocation from the sprayed foliage. The results appeared to be significant, the optical densities for the extracts of seeds and roots from the sprayed plants being 0·06–0·11 while those for extracts of the parts of untreated plants were 0·01–0·02.

(b) *Potatoes*. Collaborative work in 1960 with the West of Scotland Agricultural College on potato plants grown in soil treated with inorganic mercury compounds showed that, although the fine roots contained 0·1–0·8 p.p.m. Hg, the peel and flesh of the tubers were uncontaminated. Tests were then made in 1961 to ascertain whether mercury would occur in tubers after leaf treatment with phenylmercuric acetate.

Plants of Arran Pilot grown in pots in the glasshouse were sprayed with a proprietary wash (0·005 per cent Hg) with the addition of 1 ml. Ethylan C.P. per gallon. Treatment was first made early in June when the plants were 18″ high and repeated early in July ; the soil surface was protected with polythene. Before analysis in mid-July, the tubers were washed free from soil and well scrubbed. The results on tubers from individual plants are given in Table II.

TABLE II.

MERCURY IN POTATO TUBERS AFTER LEAF TREATMENT.

Treatment	*Peel*		*Flesh*	
	Wt.(g.)	Hg (p.p.m.)	Wt.(g.)	Hg (p.p.m.)
Sprayed	94	0·18	290	0·21, 0·21
Sprayed	96	0·13	472	0·15
Unsprayed ..	120	0·01	790	0·01

The roots from one of the sprayed plants were well washed and analysed ; they contained 1·16 p.p.m. Hg. The value for the roots from an untreated plant was 0·01 p.p.m.

Considerable contamination of the tubers followed leaf treatment with phenylmercuric acetate. The values of 0·01 p.p.m. Hg (optical densities 0·03,

reagent blank 0·01) found in the peel and flesh of the tubers from the untreated plants may represent small amounts of naturally occurring mercury.

Mercury deposits in apple fruits.

Bramley apple trees of moderate size grown in hedge-row formation were hand-sprayed to run-off with the proprietary phenylmercuric acetate wash (0·005 per cent Hg) containing added Ethylan C.P. wetter (3½ fl. oz. per 100 gallons). The applications were carefully made, using a twin-boom knapsack sprayer ; each tree received 2 gallons of wash at each application. The trees selected for the tests had not received mercury during the previous year. Six treatments, using one tree for each treatment, were made as follows :

Treatment	*Application dates*, 1961
A Phenylmercuric acetate+wetter	5 May, 26 May, 16 June, 7 July, 28 July.
B ,,	26 May, 16 June, 7 July, 28 July.
C ,,	16 June, 7 July, 28 July.
D ,,	7 July, 28 July.
E ,,	28 July.
F Phenylmercuric acetate alone	5 May, 26 May, 16 June, 7 July, 28 July.

The fruits were harvested at the end of September and kept in cold store until analysed during November-December. Individual analyses were made on the peel, the cores (excluding the calices) and 100 g. of the homogenised flesh from two fruits. The results, corrected for the values on the parts of fruits from unsprayed trees, are given in Table III.

TABLE III.

MERCURY DEPOSITS IN BRAMLEY APPLE FRUITS.

Treatment	Av. wt. of fruit (g.)	Average %			Hg (p.p.m.)			Hg (p.p.m.) in whole fruit
		Peel	Flesh	Core	Peel	Flesh	Core	
A. 5 applications with wetter	196	12	73	15	1·46	0·10	0·16	0·27
	386	12	77	11	0·67	0·11	0·10	0·17
	243	13	71	16	1·33	0·12	0·16	0·29
B. 4 applications with wetter	207	12	72	15	1·11	0·09	0·16	0·22
	196	12	74	14	0·94	0·08	0·14	0·19
	222	11	75	14	0·99	0·09	0·16	0·20
C. 3 applications with wetter	202	12	75	13	1·05	0·09	0·18	0·21
	217	11	76	13	0·84	0·09	0·15	0·19
	207	12	76	12	0·91	0·09	0·15	0·19
D. 2 applications with wetter	184	13	74	13	0·70	0·05	0·03	0·13
	231	11	77	12	0·58	0·06	0·03	0·13
	177	13	73	14	0·77	0·05	0·03	0·14
E. 1 application with wetter	211	13	73	14	0·39	0·05	*	0·09
	193	10	77	13	0·76	0·05	*	0·11
	202	11	76	13	0·53	0·03	*	0·05
F. 5 applications without wetter	196	12	74	14	1·34	0·07	0·09	0·23
	172	14	73	13	1·00	0·07	0·12	0·24
	182	14	73	13	0·81	0·06	0·06	0·23
							*trace	

The values obtained for apparent mercury in fruits from unsprayed trees were less than 0·01 p.p.m. : the optical densities found in the analysis of 100 g. portions of peel, flesh and core were 0·03 (reagents alone 0·015).

The mean values for mercury (p.p.m.) in the fruits as analysed, for the calculated micrograms of mercury in the constituent parts of apples of normal weight (200 g.) and for the percentage distribution of mercury between peel, flesh and cores are given in Table IV.

TABLE IV.

MEAN VALUES FOR P.P.M., MICROGRAMS AND DISTRIBUTION OF MERCURY IN BRAMLEY APPLE FRUITS.

Treatment	Hg(p.p.m.)	Hg μg/fruit				Hg %		
		Peel	Flesh	Core	Whole fruit	Peel	Flesh	Core
A	0·24	29	16	4	49	59	33	8
B	0·20	24	12	5	41	59	29	12
C	0·19	21	13	4	38	55	34	11
D	0·13	18	8	1	27	67	30	3
E	0·09	13	6	*	19	68	32	*
F	0·23	28	17	2	47	60	36	4

* trace

The mercury (p.p.m.) in the fruits after harvest rose steadily to a maximum of 0·24 with increasing applications. Each application contributed something to the total eventually found ; no complete loss of mercury by weathering occurred after any application, probably due to the fact, reported earlier (2), that the mercury passed into the leaves and fruits within a few days. Of the total mercury present in the fruits, one-third was located in the flesh, a value that agreed closely with that found in 1960 (3) in fruits of the same size. Rather higher amounts of mercury were found in the peel of the fruits in 1961 than in 1960, probably because of the inclusion of the calices (which tend to accumulate deposits) with the peel in the 1961 analyses and with the cores in the 1960 tests.

The addition of wetter to the washes had little effect on the levels of deposits given by the full spray programmes (Table IV, treatments A and F). The values of 0·24 and 0·23 p.p.m. Hg found in the fruits from these treatments confirm the value found after a comparable number of applications of phenylmercuric acetate at the same rates in 1960. These values, which are considerably higher than the residues resulting from the commercial use of organo-mercury sprays, or the level of contamination (0·1 p.p.m.) which on present information is considered to present no hazard to consumers, were considered to be due to the efficient hand-spraying of the trees under experimental conditions.

Phenylmercuric acetate has a higher water-solubility than some other organo-mercurials commonly used as foliage sprays. This property is likely to influence the absorption and movement of mercury, so that results with other materials may not follow the pattern shown by the acetate.

In the report of the work done in 1960 (3) reference was made to the tolerance for lead deposits on apples. Since then, the Lead in Food Regulations, 1961 (7), to come into force on 16 April, 1962, officially limit the lead contamination of apples and pears to 3 p.p.m.

Summary.

Work is reported on the distribution of mercury in the broad bean plant, on the degree of mercury contamination of potato tubers and roots, and on the levels and distribution of mercury in apple fruits after leaf applications of phenylmercuric acetate.

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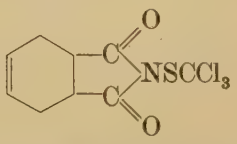
RECENT STUDIES WITH CAPTAN.

By E. SOMERS and D. V. RICHMOND.

Captan (*N*-trichloromethylthio-4-*cyclo*hexene-1,2-dicarboxyimide) was introduced by Kittleson (1) in 1952 and has rapidly established itself as one of the most successful commercial fungicides, being particularly effective against apple and pear scab. The research on captan carried out at Long Ashton over the last four years has been prompted as much by the problem of its mode of action as by its practical value. Investigations have been made of the nature of the *in vitro* reactions between captan and fungal spores and of the possible systemic action of captan in plants. As the effectiveness of a protectant fungicide such as captan is determined not only by its toxicity at the cellular level but also by the physico-chemical properties of the deposits formed on plant surfaces, studies have also been made of the tenacity, i.e. resistance to weathering, of spray deposits.

Mode of action of captan.

The structural formula of captan is :



and although the physical and chemical properties of the whole molecule will contribute to its ultimate toxicity it is now considered (see (8)) that the

$-SCCl_3$ group largely determines the biological activity of captan. Lukens & Sisler (2) consider that the $-SCCl_3$ group reacts intracellularly to form thiophosgene which is able to combine with free –SH, $-NH_2$ and possibly –COOH groups and thus inhibit vital metabolic processes. More recently extensive studies at the Boyce Thompson Institute have suggested that the direct reaction of the $-SCCl_3$ group with unprotected –SH groups in the cell is the basic toxic mechanism of captan (3,4). These workers have shown that captan can inhibit a wide rage of metabolic processes in conidia of *Neurospora sitophila* ; in the synthesis of citrate from acetate it is particularly effective against co-enzyme A, probably by oxidizing the thiol group to inactive disulphide. The inhibitory action of captan on the fermentation of glucose by *Saccharomyces pastorianus* has similarly been ascribed to reaction with thiol groups, in this instance on the glutathione prosthetic group of glyceraldehyde-3-phosphate dehydrogenase (5).

Permeation of a fungicide into a fungal cell is one of the key processes governing fungitoxicity, for it is now recognized that most agricultural fungicides act through selective accumulation by the fungal cells (6). Thus the uptake of a homologous series of fungicides has been found to be related both to lipid solubility and toxicity of the compounds (7). To determine whether similar processes control the fungitoxicity of captan we have compared its spore uptake and toxicity with those of some six analogues of widely varying lipid solubility (8). The analogues possessed the toxophoric $-NSCCl_3$ group and the phthalimide structure ; their oleyl alcohol-water partition coefficients ranged from 7 to 1400. However, only with the two least fat-soluble compounds (the endoxo- and epoxy-hexahydrophthalimides) was there a correlation between lipid solubility and the spore uptake and fungitoxicity. Apparently the other compounds could exceed the required threshold of lipid solubility and hence showed equal toxicity.

It was evident from this work that fungal spores were able to accumulate or detoxify large amounts of captan before germination was completely inhibited. Thus the ED_{50} value of captan against *Neurospora crassa* in fungicidal tests was equivalent to nearly 7,000 μg. captan/g. spore dry weight. An interesting illustration of the selective uptake of captan was given by measuring the decrease in concentration of captan solutions in contact with detached apple leaves (var. Bramley). The uptake by the leaves was only 1·1 μg. captan/g. leaf (dry weight) as compared to the spore uptake of 7,100 μg. captan/g. spore of *N. crassa* in the same time period.

Further investigation was made of the factors controlling the uptake of captan, from aqueous solution, by dense suspensions of *N. crassa* spores (9). The uptake process was found to deviate from normal diffusion in the effects of temperature, inorganic salts, presence of oxygen, and enzyme poisons. The results suggest that captan is taken up from solution by a process requiring cell metabolic energy, i.e. an active transport mechanism. Although there was a large decrease in the supernatant concentration of captan solutions in contact with spores, no undecomposed captan could be recovered from the cells. Even when captan was labelled with the radio-tracer ^{35}S no more than 0·5% of the captan lost from solution could be detected in the spores (10). The actual site of this decomposition of captan, whether at the cell surface or within the cell, is at present unknown. However, as captan was not decomposed either by dead

cells or by cell fragments, and as the uptake process is dependent on cell metabolism, it would seem that decomposition probably takes place on or within the cell protoplast—a view reinforced by the relatively slow rate of captan uptake, indicating permeation of the cell rather than adsorption.

When spores of *N. crassa* were pre-treated, before exposure to captan, by bathing them in solutions of such thiol reagents as iodoacetic acid or *p*-chloromercuribenzoate they showed very little ability to take up captan. In fact pre-treatment of the spores with 4×10^{-4}M iodoacetic acid reduced captan uptake to 16% of the control and yet did not alter the concentration level of captan required to inhibit spore germination. Now the reaction between *p*-chloromercuribenzoate and –SH groups, in contrast to that with iodoacetic acids, can be reversed by further treatment with such thiols as 2,3-dimercaptopropanol (BAL) and we have found that the inhibition of captan uptake given by *p*-chloromercuribenzoate can, similarly, be reversed by post-incubation with BAL.

These results suggest that although captan will react freely with –SH groups in the cell, this reaction may well be irrelevant to its ultimate toxic action. Certainly the high level of captan uptake achieved could result from cellular detoxication rather than reaction at vital sites. Further work is in progress to determine quantitatively the –SH level of different species of fungi to see whether this correlates with captan uptake from solution (11). Amperometric titration with silver ions has shown the –SH content of spores of *N. crassa* to be very much greater than that of *Alternaria tenuis*, in agreement with the greater captan uptake of the former. Recent studies also suggest that the initial reaction of captan with the spores will denature cell protein and so expose further –SH groups for detoxication of the captan.

Systemic action of captan.

Numerous claims have been made that captan possesses systemic activity ; root application of the fungicide has been reported to increase control of leaf infections on such diverse plants as cucumber, broad bean, rose, and pea. However, unequivocal proof of systemic action can only be given by chemical identification of the fungicide in those parts of the plant not in direct contact with the fungicide. Recently, Wallen & Hoffman (12) reported that chemical analysis could detect up to 0·85 p.p.m. (fresh weight) of captan in pea seedlings whose roots had been watered with captan solutions.

A more sensitive analysis is provided by the use of a radio-tracer and we have used this technique to follow the translocation of captan, labelled with ^{35}S, in broad bean plants (13). Captan solutions were applied daily to the roots of the beans so that each plant ultimately received 3,400 μg. captan. After nine days the leaflets, petioles, apical and flower buds were harvested and subjected to a cold benzene extraction. Counting of the benzene extracts with a Geiger-Müller tube showed that the maximum radioactivity in any plant was equivalent to 0·09 p.p.m. (fresh weight) captan : many plants gave counting values hardly different from that of the background. In these circumstances the amount of captan translocated is such a very small proportion of that applied to the roots that chemotherapeutic effects cannot be attributed to systemic activity. As captan is known to inhibit metabolic processes in plants (14) it is more probable that the increased resistance to fungal attack

results from changes in host metabolism rather than from the presence of translocated captan in the plant tissue.

Tenacity of spray deposits of captan.

It has been established for many fungicides that the tenacity of spray deposits increases with decreasing size of the particles. The greater surface area per unit weight and the greater deformability of the smaller particles increases their adhesion to the leaf surface. Determinations of the tenacity of a number of particle size ranges of captan, from 0–2 μ to 30–40 μ, on a variety of leaf surfaces have shown essentially similar behaviour for captan (15). The tenacity of captan deposits on different types of leaf and artificial surfaces has been found to be related to the wettability of the surfaces, as measured by the static contact angle of water droplets. Thus, for equivalent captan deposits of 1 μg./sq. cm. the order of retention of the following surfaces is :—

broad bean>cellulose acetate>black currant>apple>laurel>banana, which is also their order of decreasing wettability.

The tenacity of captan deposits has been found to increase sharply with decreasing size of deposit, which suggests that the cohesive forces between the particles are less than the adhesive particle-surface forces (16). These results are in complete opposition to the behaviour of Bordeaux mixture (17) and explain the continued persistence of low levels of captan in the field. Further work is in progress to correlate the chemical assessments of tenacity with the biological properties of captan spray deposits.

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STUDIES ON PLANT CUTICLE: PROGRESS REPORT.

By E. A. BAKER, R. F. BATT, MARGARET F. ROBERTS* and J. T. MARTIN.

During 1961, work was continued on the formation of the cuticles of apple leaves and fruits during growth, on the cuticles of apple fruits in storage and on the cuticles of lime leaves in relation to fungal invasion. New work was begun on the chemistry of cutin. This report also contains accounts of work on the morphology of the leaf cuticle and on the cuticles of lime leaves carried out by Margaret F. Roberts before leaving Long Ashton.

The morphology of the leaf cuticle of *Euonymus japonicus* (Linn.) F.

The chief components of the leaf cuticle are cutin and waxes. According to the modern view, which accords well with the conclusions of earlier workers, the cutin forms a protective membrane with the waxes embedded within it and protruding from its surface, giving the leaf its water-repellent property. Cellulose and pectin occur along with the cutin in the inner region of the membrane where it merges into the outer walls of the epidermal cells.

E. japonicus is an ornamental shrub commonly found in coastal districts in southern England. Its leaves often show severe infection by mildew. Earlier work (1, 2) on its leaf cuticle in relation to fungal invasion showed a well-formed cuticular membrane containing 0·6 mg. of cutin/cm.^{2} of surface. The upper stomata-free cuticle of the leaf was therefore selected for histological tests. Surface waxes were removed by dipping leaves in four successive portions of chloroform; discs of 3 cm.^{2} area were then punched from the leaves and extracted with ether to remove occluded waxes, and methanol to remove pigments. The cuticular membranes were detached by refluxing the discs in 1·6 per cent ammonium oxalate –0·4 per cent oxalic acid solution and refluxed successively in 1·25 per cent sulphuric acid and 0·2 per cent potassium hydroxide solutions. At this stage, the membranes retained remnants of the epidermal cells (Plate X, Fig. 1); these were removed by treatment with cuprammonium solution, leaving the membranes as translucent sheets.

The membranes were fixed in alcohol/acetic acid/formalin solution, dehydrated and wax embedded for sectioning. Safranin or Sudan IV was used to stain cutin, aniline blue to stain cellulose, ruthenium red to stain pectin and methyl green to detect cellulose and pectin occurring together. The detection of cellulose with aniline blue was facilitated by brief treatment of the membrane, before staining, with ethanolic potassium hydroxide solution. Cutin was shown to occur throughout the membrane (Fig. 2) and positive reactions were obtained for cellulose (Fig. 3) and pectin (Fig. 4) within the innermost half of the membrane. Gradations in colour showed that the cellulose and pectin were concentrated most strongly in the zone nearest the epidermal cells. Examination of the membrane using crossed nicols showed an outermost strongly isotropic band due to cutin, an intermediate birefringent band due to cellulose and an innermost isotropic area due to pectin; sections treated with ethanolic potassium hydroxide solution showed an intermediate zone of enhanced birefringence due to the partial removal of cutin and leaching of the pectin.

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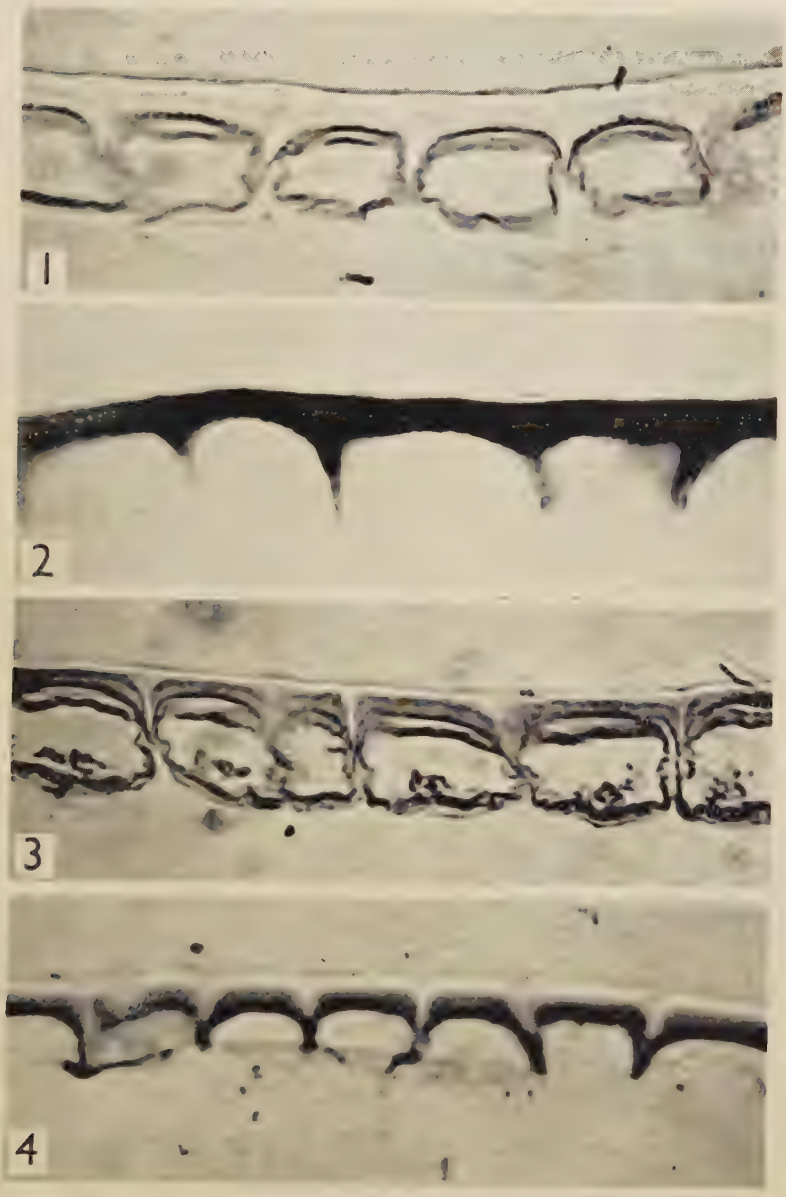

Fig. 1. Membrane with remnants of epidermal cells, unstained.
Fig. 2. Membrane, epidermal cell remnants removed, stained with Sudan IV.
Fig. 3. Membrane with remnants of epidermal cells, stained with aniline blue.
Fig. 4. Membrane, epidermal cell remnants removed, stained with ruthenium red.

The results fully confirmed the present conception of the structure of the leaf cuticle. That the cellulose and pectin within the inner portion of the membrane were firmly held and protected by the cutin was shown by the failure of the solvents to remove the pectin during the preparation of the membranes and by the fact that the embedded cellulose could be stained satisfactorily only after partial saponification of the cutin.

Surface waxes and cutin on expanding leaf surfaces.

Further tests were made to determine the surface deposits and the rates of production of waxes and cutin in leaves as they grew to full size. Analyses were made by the methods already described (3) ; surface waxes were removed by four immersions in chloroform at room temperature, the cuticular membranes were isolated by oxalate treatment, and cutin was determined by loss in weight on saponification.

Surface waxes were determined on leaves of increasing size along shoots of MM.106 apple rootstocks in the nursery. The third leaves (average size 6 cm.^{2}) were the smallest that could be tested ; full size (21 cm.^{2}) was attained by the sixth leaves from the apices of the shoots. The first immersions removed 61–74 per cent and the fourth immersions 4–9 per cent of the total waxy materials obtained. The results are shown in Table I.

TABLE I.

SURFACE WAXES ON MM. 106 APPLE ROOTSTOCK LEAVES

	Average size of leaf (cm.^{2})					
	6·0	11·0	13·7	16·5	19·7	21·1
Average wt. of leaf (g.)	0·13	0·23	0·30	0·35	0·46	0·55
Average wt. of 1 cm^2. disc (mg.) ..	21·6	20·9	21·9	21·2	23·4	26·1
Surface waxes* (mg./cm.^{2}) ..	0·04	0·04	0·03	0·03	0·03	0·04
Surface waxes per leaf (mg.) ..	0·47	0·76	0·89	1·09	1·33	1·62

*Mean deposit for both surfaces.

The values for surface waxes and cutin on Cox apple leaves from the orchard are shown in Table II.

TABLE II.

SURFACE WAXES AND CUTIN ON COX APPLE LEAVES.

	Average size of leaf (cm.^{2})					
	3·5	4·3	7·3	12·0	14·7	19·1
Average wt. of leaf (g.)	0·07	0·08	0·14	0·25	0·34	0·41
Average wt. of 1 cm.^{2} disc (mg.) ..	20·0	18·6	19·2	20·8	23·1	21·5
Surface waxes* (mg./cm.^{2}) ..	0·03	0·04	0·05	0·05	0·05	0·07
Cutin* (mg./cm.^{2})	0·06	0·04	0·05	0·04	0·05	0·07
Surface waxes per leaf (mg.) ..	0·24	0·37	0·79	1·13	1·47	2·48
Cutin per leaf (mg.)	0·42	0·32	0·76	1·06	1·32	2·67

*Mean deposit for both surfaces.

The results, plotted in Fig. 5, showed that the deposits, as mg./cm.^{2}, of surface waxes and cutin remained approximately constant during the inter-

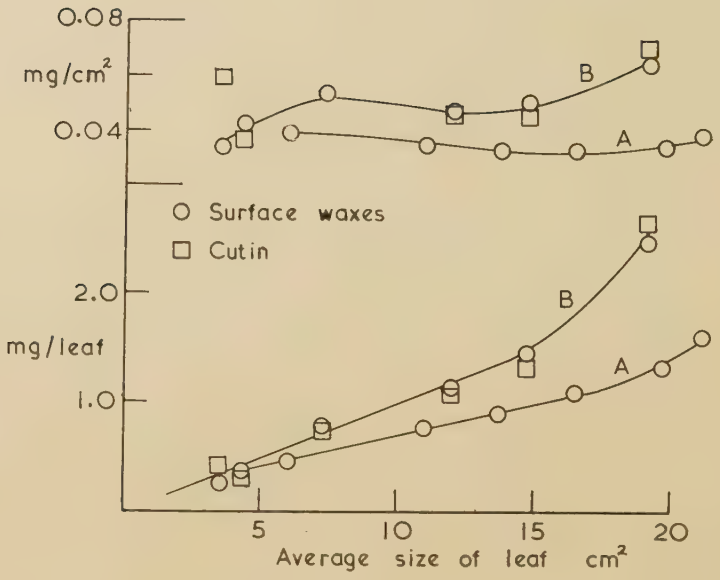

Fig. 5. Surface deposits and cumulative production of waxes and cutin in MM.106 (A) and Cox (B) apple leaves.

mediate periods of growth, and that during these periods surface waxes and cutin were produced by the leaves at constant rates. There were indications that after the leaves were about three-quarters fully grown, the rates of production of surface waxes and cutin accelerated; increases in the weight/size relationship were also seen as the leaves reached full size.

Comparisons were also made of the surface waxes and cutin on the leaves of MM.106 rootstocks and apple seedlings growing in the nursery beds and in the glasshouse. The eleventh and twelfth leaves along the shoots were used; those from the rootstocks were unusually large. Cutin was determined separately in the upper and lower cuticular membranes. The results are given in Table III.

TABLE III.

SURFACE WAXES AND CUTIN ON APPLE LEAVES IN THE OPEN AND UNDER GLASS.

	MM.106		Seedlings	
	In open	Under glass	In open	Under glass
Average size of leaf (cm.²)	33·4	45·1	22·4	21·9
Average wt. of leaf (g.)	0·74	0·91	0·52	0·40
Average wt. of 1 cm.² disc (mg.) ..	22·1	20·2	23·2	18·3
Surface waxes* (mg./cm.²) ..	0·02	0·03	0·03	0·03
Surface waxes per leaf (mg.) ..	1·47	2·43	1·52	1·27
Cutin upper surface (mg./cm.²) ..	0·05	0·06	0·12	0·12
Cutin lower surface (mg./cm.²) ..	0·05	0·06	0·09	0·07
Cutin per leaf (mg.)	3·41	5·40	4·55	4·20

*Mean deposit for both surfaces.

The leaves of the rootstocks in the glasshouse grew to a large size, but showed the same weight/size relationship and the same surface deposits of waxes and cutin as those grown outside. To maintain their surface deposits, the leaves under glass produced considerably more waxes and cutin than those in the open. By contrast, the leaves of the seedlings under glass differed only slightly from those outside.

Waxes on the upper and lower surfaces of apple leaves.

The ability to isolate the upper and lower cuticular membranes separately after oxalate treatment permitted the determination of cutin in the upper and lower surfaces of leaves, but the immersion of leaves in chloroform to determine surface waxes gave only a mean value for both surfaces. Qualitative tests in which waxes were washed from the upper or lower surfaces of apple leaves showed that more waxy material occurred on the lower surfaces and that it contained a higher proportion of the low-melting paraffinic compounds, or true wax, precipitated by acetone. A material insoluble in chloroform was then sought by which the upper or lower surfaces could be protected during the immersion process. A thin film of a viscous, aqueous paste of the proprietary Aerolite 306 adhesive powder (no hardener), which set after 2 hours, was found to be satisfactory. Waxes were obtained separately from the upper and lower surfaces of young Cox and Worcester (6 cm.^{2} size) and fully-grown MM.106 leaves, acidic compounds were removed by titration with dilute alkali from ether solution, and the paraffinic compounds were separated from the oil by partition between *n*-heptane and methanol (3). The results are given in Table IV.

TABLE IV.

WAXES ON THE UPPER AND LOWER SURFACE OF APPLE LEAVES.
(mg./cm^2.)

	MM 106		Cox		Worcester	
	Upper surface	Lower surface	Upper surface	Lower surface	Upper surface	Lower surface
Surface waxes	0·03	0·04	0·03	0·04	0·03	0·05
True wax	0·01	0·02	0·01	0·02	0·01	0·02
Acids	0·01	0·01	0·01	0·01	0·01	0·02
Oil	0·01	0·02	0·01	0·01	0·01	0·01

More waxy material, and more true wax, was found on the lower than on the upper surfaces of the leaves. Even greater differences were found in work carried out on the upper and lower surface waxes of black currant leaves in connection with the deposition of spray materials.

The cuticles of lime leaves.

Work was continued on the cuticles of lime leaves in relation to infection by the fungus *Gloeosporium limetticola* Clausen (2). Tests were made on young leaves that were hardening and losing susceptibility to the fungus and on older non-susceptible leaves, sent from Zanzibar. Surface waxes were removed by immersion in chloroform, absorbed waxes by the Soxhlet extraction of discs after immersion, and cutin was assessed from the weight of cutin acids recovered after saponification. The results are given in Table V.

TABLE V.

WAXES AND CUTIN OF LIME LEAVES.

	Young, losing susceptibility	Old non-susceptible
Average size of leaf (cm.²)	7·4	15·2
Average wt. of leaf (g.)	0·15	0·36
Average wt. of 1 cm.² disc (mg.)	20·2	23·7
Surface waxes* (mg./cm.²)	<0·01	<0·01
Absorbed waxes* (mg./cm.²)	0·06	0·07
Cutin, upper surface (mg./cm.²)	0·08	0·25
Cutin, lower surface (mg./cm.²)	0·06	0·16

*Mean deposit for both surfaces.

Very little surface wax occurred on the young or old leaves, and much higher levels of cutin were found in the old than in the young leaves.

Earlier work (2) showed that the absorbed waxes and cutin acids of rose leaves suppressed the germination of mildew spores. The lime leaf fractions were therefore tested on spores of *G. limetticola* sent from Zanzibar and cultured on potato-dextrose-agar medium. Spore suspensions (50,000/ml. in 1 per cent glucose solution) were placed on thin films of the materials deposited from chloroform solution in flat-bottomed cavity glass slides and kept at 25°C for 1 day. Stearic acid and paraffin wax (m.p. 55°C) were included as controls; the mean germination values are given in Table VI.

TABLE VI.

EFFECT OF LIME LEAF CUTICLE COMPONENTS UPON SPORES OF *GLOEOSPORIUM LIMETTICOLA*.

	Per cent germination	
	Young, losing susceptibility	Old non-susceptible
Surface waxes	68	56
Absorbed waxes	0	1
Cutin acids, upper surface ..	20	4
Cutin acids, lower surface ..	36	10
Stearic acid	 60	
Paraffin wax	 53	
Solvent	 53	
No treatment	 62	

The absorbed waxes suppressed germination and the cutin acids from the old leaves appeared more active than those from the young leaves. Effects of this kind have already been discussed (2, 4); whether they play any part in the resistance of leaves to fungi is not known.

The cuticles of apple fruits during growth.

In previous work on fruits (5), discs of peel were taken after washing off the surface waxes, the flesh was removed as cleanly as possible by scraping, and the cuticular membranes were isolated by oxalate treatment. Substances may

have been lost from the cuticles by these treatments and adhering flesh may have influenced the results; a less drastic method was therefore sought of obtaining cleaner membranes. Incubation of peel discs, after removing the waxes, with a proprietary pectin enzyme (Pektolase GV, 2 per cent in phosphate-citric acid buffer solution at pH 3·5) at 37°C proved satisfactory; after 1–2 days membranes were obtained which occluded little more than the epidermal cells.

The following procedure was adopted for the examination of the fruit cuticles. Discs of 1 cm.^{2} (50) with as little flesh as possible were washed by decantation with four portions of chloroform to remove surface waxes, dried at 40°C overnight and Soxhlet-extracted with chloroform to remove the absorbed waxes. Separate tests showed that waxy material contributed by the adhering flesh was negligible. The membranes were then isolated with pectin enzyme and after successive methanol, dilute sulphuric acid and dilute aqueous potash treatments were saponified to give an assessment, by weight, of cutin. At each stage of analysis after isolation, the dried membranes were weighed to determine the progressive losses due to the treatments.

Changes in the cuticles of Dabinett and Dove cider apples, chosen because of their differing susceptibilities to the scab fungus, were followed during their growth. The results are given in Table VII.

TABLE VII.

CUTICLES OF DABINETT AND DOVE APPLE FRUITS DURING GROWTH

	3 July	15 July	29 July	12 Aug.	26 Aug.	8 Sept.
Dabinett						
Average wt. of fruit (g.)	10·1	14·7	18·3	20·5	22·3	24·4
Average surface area (cm.^{2})	21	27	30	33	35	37
Surface waxes (mg./cm.^{2})	0·45	0·39	0·42	0·44	0·45	0·47
Absorbed waxes ,,	0·13	0·26	0·26	0·31	0·34	0·26
Cuticular membrane ,,	1·43	1·48	1·44	1·54	1·63	1·55
Cutin ,,	0·69	0·73	0·80	0·87	0·88	0·91
Complete cuticle ,,	2·01	2·13	2·12	2·28	2·42	2·29
Dove						
Average wt. of fruit (g.)	8·9	12·6	14·1	17·9	21·5	24·6
Average surface area (cm.^{2})	21	26	28	32	37	39
Surface waxes (mg./cm.^{2})	0·43	0·40	0·46	0·48	0·49	0·51
Absorbed waxes ,,	0·09	0·22	0·17	0·20	0·15	0·22
Cuticular membrane ,,	0·96	1·02	1·19	1·13	1·04	1·09
Cutin ,,	0·55	0·56	0·76	0·66	0·59	0·64
Complete cuticle ,,	1·48	1·64	1·82	1·81	1·68	1·82

Throughout the growth of the fruits, the wax-free cuticular membranes and the complete cuticles (made up of the membranes and waxes) of the Dabinett fruits were heavier than those of Dove.

The percentages of waxes and cutin in the complete cuticles are shown in Table VIII.

Although there was a much heavier deposition of cutin in the Dabinett fruits, the percentages of cutin in the Dabinett and Dove cuticles were about the same. The percentages of surface and total waxes in the Dove cuticles were consistently higher than those of Dabinett. Most of the " other material " was

TABLE VIII.

PERCENTAGE COMPOSITION OF THE CUTICLES OF DABINETT AND DOVE APPLE FRUITS.

	3 July	15 July	29 July	12 Aug.	26 Aug.	8 Sept.
Dabinett						
Surface waxes	22	18	20	19	19	21
Total waxes	29	31	32	33	33	32
Cutin	34	34	38	38	36	40
Other material	37	35	30	29	31	28
Dove						
Surface waxes	29	24	25	27	29	28
Total waxes	35	38	35	38	38	40
Cutin	37	34	42	36	35	35
Other material	28	28	23	26	27	25

extracted from the membranes by the dilute aqueous potash immediately before saponification; the chemical nature of this fraction is under examination. From these results the only factor that seemed likely to account for the greater resistance of the Dabinett fruits to scab was the heavier deposition of cutin in their skins.

The changes in surface deposits and the cumulative production of waxes and cutin in the Dabinett fruits during growth are plotted in Fig. 6. The picture was similar to that for leaves (Fig. 5); waxes and cutin were produced at constant rates as the fruits increased in weight.

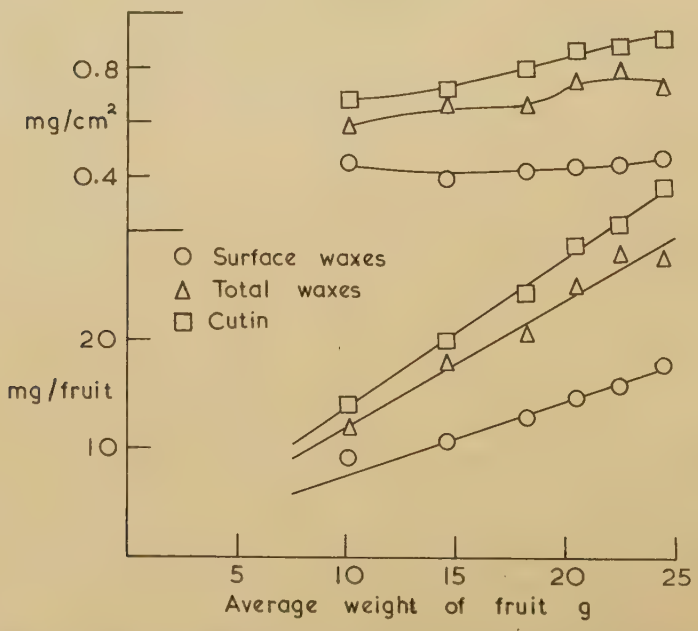

Fig. 6. Surface deposits and cumulative production of waxes and cutin in Dabinett apple fruits.

The cuticles of apple fruits in storage.

Tests using the enzymic method of isolating the cuticular membranes were made on two samples of Cox apples soon after harvest and on the Cox and on Laxton's Superb, Winston and Howgate Wonder apples after three months in storage in a cold room. The results are given in Table IX.

TABLE IX.

CUTICLES OF COX, LAXTON, WINSTON AND HOWGATE WONDER APPLE FRUITS AFTER STORAGE.

	After harvest		After 3 months' storage				
	Cox A	Cox B	Cox A	Cox B	Laxton	Winston	Howgate
Average wt. of fruits (g.) ..	102	109	100	88	109	105	343
Average surface area (cm.^{2}) ..	92	95	95	87	97	—	209
Surface waxes (mg./cm.^{2}) ..	0·74	0·72	0·73	0·79	0·60	0·68	0·62
Absorbed waxes „ ..	0·53	0·51	0·60	0·62	0·40	0·52	0·20
Cuticular membrane „ ..	1·49	1·52	1·57	1·69	1·44	1·62	1·30
Cutin „ ..	0·64	0·67	0·80	0·81	0·84	0·97	0·90
Complete cuticle „ ..	2·76	2·75	2·90	3·10	2·43	2·83	2·13

There was an indication of continued production of waxes and cutin in the Cox apples, but this effect may have been exaggerated by some shrinkage of the cuticles during storage. The percentage compositions of the cuticles are shown in Table X.

TABLE X.

PERCENTAGE COMPOSITION OF CUTICLES OF COX, LAXTON, WINSTON AND HOWGATE WONDER APPLE FRUITS.

	After harvest		After 3 months' storage				
	Cox A	Cox B	Cox A	Cox B	Laxton	Winston	Howgate
Surface waxes	27	26	25	25	25	24	29
Total waxes	46	45	46	46	41	43	39
Cutin	23	24	28	26	35	34	43
Other material	31	31	27	28	25	23	19

The complete cuticles of Cox were as heavy as those of Laxton and Winston, but contained much less cutin and higher proportions of waxes and other material. Howgate Wonder was characterized by a light cuticle with a relatively high content of cutin, but in no cuticle did the cutin content exceed 50 per cent.

The chemical nature of cutin.

Although cutin forms the chief structural component of plant cuticles, little is known of its chemistry. Fremy in 1859–85 isolated from the cutin of a species of *Agave* and other plants a solid, stereocutic acid (m.p. 76°C), and a semi-liquid, oleocutic acid. Legg and Wheeler in 1925–9 resolved the cutin of *A. americana* into cutic acid, ($C_{26}H_{50}O_6$) and cutinic acid ($C_{13}H_{22}O_3$) and concluded that Fremy's oleocutic acid was a mixture of these compounds. Beatrice Lee in 1925, after work on flower petal and rhubarb cuticle, considered that cutin was a complex mixture of acids with other materials that had undergone conden-

sation and oxidation. More recently, Huelin and his co-workers (6, 7) showed that apple fruit cutin on saponification gave complex hydroxy acids and considered that cutin was formed by their condensation by means of ester linkages, a view that is generally accepted. From the cutin of leaves of *A. americana*, Matic (8) obtained and characterized four acids, namely (i) *threo*-9:10:18-trihydroxyoctadecanoic (phloionolic, $CH_2OH(CH_2)_7CHOH.CHOH(CH_2)_7COOH$), (ii) 10:18-dihydroxyoctadecanoic, (iii) 18-hydroxyoctadecanoic and (iv) 10:16-dihydroxyhexadecanoic ($CH_2OH(CH_2)_5CHOH(CH_2)_8COOH$); a fifth, 18-hydroxyoctadec-*cis*-9-enoic acid was isolated as its dihydroxy derivative. The chief acid, phloionolic, comprised 43 per cent of the ether-soluble acids derived from the cutin.

Mixtures of cutin acids were obtained from large batches of Cox apple leaves and fruits by following the procedure of the analytical method. Preliminary fractionation based on the solubilities of the potassium salts in alcohol and the formation of urea complexes showed the same basic pattern of cutin acids in the leaves and fruits, with a higher proportion of a liquid component in the fruit cutin. A compound, m.p. 76°C, shown by infra-red analysis to be a hydroxylated aliphatic acid, was obtained pure from both leaves and fruits.

The cuticles from a large quantity of Dabinett apples were obtained by boiling the fruits in water, flesh was removed by boiling with 1 per cent sulphuric acid, and the dried membranes were exhaustively extracted with methanol to remove waxes. The membranes were saponified with 3 per cent ethanolic potassium hydroxide at room temperature, the cutin acids recovered in ether solution, washed out with bicarbonate solution and again taken up in ether. The solvent was removed and the cutin acids allowed to crystallize from ethyl acetate solution; two main crops of crystals were obtained and recrystallized to constant melting point from ethanol-petroleum ether or methanol-water mixtures. Infra-red analysis indicated that the compounds were hydroxylated fatty acids; equivalent weights were determined by titration of benzene-methanol solutions, under nitrogen, with potassium methoxide (9). The properties of the compounds were as follows:

Compound I. Weight obtained 3·7 g.: m.p. 99–100°C uncorrected: C, 64·9, 64·9; H, 10·9, 11·3%: saturated acid, equivalent weight 324: molecular formula $C_{18}H_{36}O_5$.

Calculated for trihydroxyoctadecanoic acid, $C_{18}H_{36}O_5$: C, 65·0; H, 10·9%: equivalent weight 332.

Compound II. Weight obtained 2·7 g.: m.p. 75–6°C uncorrected: C, 66·1, 66·2: H, 11·2, 11·3%: saturated acid, equivalent weight 292: molecular formula $C_{16}H_{32}O_4$.

Calculated for dihydroxyhexadecanoic acid, $C_{16}H_{32}O_4$: C, 66·6; H, 11·2%: equivalent weight 288.

Another crop of crystals (0·24 g.) was obtained and recrystallized to constant melting point from methanol-water (m.p. 84°C uncorrected; equivalent weight 312).

The largest fraction of the cutin acids consisted of an oil (11·0 g.) from which a further amount of compound I was isolated by column chromatography. The oil gave a positive test for unsaturation and by infra-red analysis showed hydroxy fatty acid structure with an indication of *cis* double bond configuration, but further resolution is required.

The positions of the hydroxyl groups in compounds I and II have not been determined, but from a comparison of properties there is little doubt that these cutin acids from apple fruits are identical with acids obtained by Matic from *Agave* leaves. This raises the interesting question of the extent to which the cutin acids vary in kind and amount in the cutin of different plants. Work on other plant cutin is in progress.

Summary.

Work is described on the morphology of the leaf cuticle, on the production of waxes and cutin by apple leaves and fruits during growth, on the cuticles of apple fruits in storage, on the cuticles of lime leaves in relation to fungal invasion, and on the chemical nature of cutin.

Acknowledgments.

We are indebted to Dr. B. E. J. Wheeler of the Department of Agriculture, Zanzibar, for the supply of lime leaves and fungus, to Dr. R. J. W. Byrde for the fungitoxicity tests and to Mr. D. R. Clifford for the elemental analyses of the cutin acids.

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STUDIES ON LIQUID SURFACES: II. DYNAMIC AND STATIC SURFACE TENSIONS OF SOLUTIONS OF TWO SODIUM DIALKYL SULPHOSUCCINATES IN WATERS OF DIFFERENT HARDNESS.

By W. D. E. THOMAS and L. POTTER.

Surface active agents play important roles in the preparation and application of horticultural sprays. The ability of a compound to assist emulsification, wetting or spreading is due to the fact that its molecules are composed of water-soluble and water-repellent groups. When such a compound is dissolved in water, molecules move to the surface and orientate themselves with the water-soluble part anchored in the surface and the water-repellent group extending above it; the resulting modification of the surface is indicated by a reduction in the surface tension of the solution.

The efficiency of surfactants is usually assessed by measurement of the surface tensions of their aqueous solutions under equilibrium conditions, i.e. after the movement of molecules to the surface is completed, and the values so obtained are known as static surface tensions. The movement of molecules to the surface, however, is not instantaneous, and may take 0·1 sec. or more before it is substantially complete. Whilst this movement is occurring, the tension falls from the value for water to the equilibrium value for the solution; the intermediate tension values are termed dynamic tensions and are dependent on the age of the surface. Successive stages in a spraying process (e.g. the formation of droplets, and the impaction of the liquid upon a leaf) are characterized by continual changes in the liquid surface, which may be too rapid to permit equilibrium in the surface to be attained; conclusions based on the static or equilibrium tension value of the solution would in these cases give a misleading assessment of the efficiency of the surfactant. It is for such dynamic systems that a knowledge of the change of tension with time is essential to a more dependable appraisal of surface active agents.

The oscillating jet procedure based on the classical Bohr theory (1) was developed as described in Part I to measure the rates at which solutions of surface active compounds attain their equilibrium surface tensions; results for pure water very near to the classical value (72·8 dynes/cm. at 20°C) were obtained using several orifice tubes and different flow rates (2). These determinations were made during the initial ageing period of 20 millisec. It was subsequently found, however, that solutions of two sodium dialkyl sulphosuccinates required up to 100 millisec. for appreciable ageing, and modifications to the original apparatus thus became necessary to extend the age range. This paper gives the results obtained with these surfactants in waters of different hardness.

Experimental.

The first solution to be investigated using the apparatus previously described was 0·04% aqueous heptanol (commercial grade). The results obtained were very similar to those of Defay and Hommelen (3), the tension of the newly formed surface falling from the water value of 73 dynes/cm. to

55 dynes/cm. at 20°C after 10 millisec. In subsequent experiments with 0·025% and 0·05% aqueous solutions of sodium di(2-ethylhexyl) sulphosuccinate it became clear that this compound, as well as the dinonyl homologue, attained its equilibrium tension at a slower rate than heptanol. The wider age range was studied by using elliptical orifices of the same design but larger bore (1·5 mm.). These new orifices were extremely sensitive to vibrational disturbances, and a substantial re-design of the constant pressure head apparatus became necessary. The solution was contained in a 10 litre reservoir and allowed to flow at a controlled rate into a constant level apparatus, so that the pressure head, and therefore the flow-rate through the orifice, was constant. The apparatus stood on a concrete block resting on anti-vibration mountings (4).

The stream was illuminated and the wavelength and flow rate determined as before (2). By using a N.P.L. standardized gauge wire of about the same diameter as the stream, the radius of these wider streams could be determined to within about 0·2%. The construction of a precision camera stand permitting movement in two directions at right angles to each other enabled the profile of every wave along the stream to be determined.

The surface tension γ corresponding to the midpoint of each wave minimum was calculated from the Bohr equation (2), in which γ is a function of the wavelength, stream radius and flow rate. The corresponding surface ages were assumed to be equal to the distance from the orifice divided by the linear velocity of the stream. Equilibrium surface tensions were determined by means of the Du Noüy tensiometer, and the values corrected using the tables of Harkins and Jordan (5).

Results with water.

The results obtained with glass-distilled water were found to be dependent on (a) the divergence of the orifice tube from the horizontal, (b) the flow rate and (c) the wave measured. Because of this, determinations were made using a particular flow rate and setting of the orifice tube. All solution results at this flow rate and setting were then corrected according to the equation.

$$\gamma_{corr.} = \gamma_{expt.} \times 72{\cdot}8/\gamma_{expt.\ H_2O} \text{ at } 20°C$$

where $\gamma_{expt.\ H_2O}$ and $\gamma_{expt.}$ are the corresponding tension values for the water and solution stream at the same surface age. Good agreement was found for solutions using various orifice tubes and flow rates after correction from the corresponding water values.

With any particular setting both permutit demineralized water and Bristol tap water gave the same tension values at corresponding waves—i.e. the wavelength and stream radius values were identical at the same flow rate.

Dynamic tensions of sodium dialkyl sulphosuccinates.

Tests were made on dilute aqueous solutions (0·025 and 0·05 per cent) of two anionic surface active compounds, sodium di(2-ethylhexyl) sulphosuccinate (DEHS) and sodium dinonyl sulphosuccinate (DNS) which are extensively used as spray adjuvants. The materials were commercially pure (nominally 100%), small amounts of sodium sulphate being present. They were dried at 40°–50°C to constant weight before use.

Solutions in distilled water

The results (Fig. 1) indicate that at both concentrations the dinonyl compound showed a greater fall of surface tension than the di(2-ethylhexyl) derivative. The initial rates of fall, somewhat similar for the two compounds at the same concentration, were greater at the higher concentration than at the lower. The equilibrium tensions of these solutions representing the terminal stage of the ageing process are also shown for each solution. No differences in ageing behaviour were found when permutit demineralised water was used instead of distilled water for preparing the solutions.

Since distilled water is not used in field practice, a further study was made of the behaviour of the two compounds in two tap waters of different hardness - hard Bristol tap water and moderately soft Swansea water (Table 1).

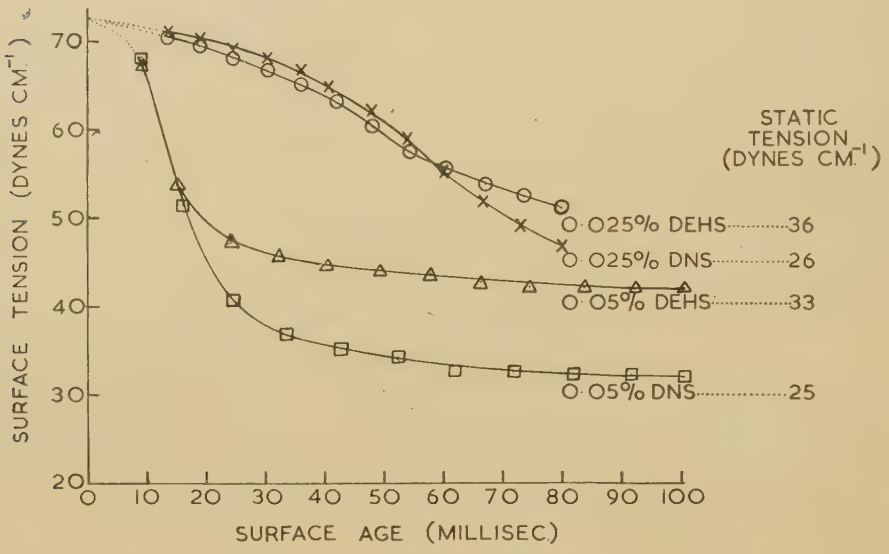

*Fig.*1. Dynamic and static tensions of sodium di(2-ethylhexyl) sulphosuccinate and sodium dinonyl sulphosuccinate solutions in distilled water at 20°C.

DEHS in tap waters (Fig. 2)

At both concentrations small amounts of bivalent cations in the water (Swansea soft water) markedly increase the rate of fall of tension compared with the corresponding rates in distilled water. Thus whilst the tension of a 0·05% solution in distilled water fell to 45 dynes/cm. (at 20°C) in about 40 millisec. after surface formation, the tension at this concentration in soft water fell to about 34 dynes/cm. in the same time. At the lower concentration (0·025%) the effect was even more marked, the tensions at surface-ages greater than about 35 millisec. being lower than those of the 0·05% solution in distilled water. Burcik (6) reported similar effects when cations were added to anionic surface active compounds, and suggested that the increased rate might be due to a reduction in potential at the interface, due to the added cations, which facilitated the attainment of equilibrium.

TABLE I.

PROPERTIES OF SOLUTIONS OF SODIUM DI(2-ETHYLHEXYL) AND SODIUM DINONYL SULPHOSUCCINATES.

Type of Water	Distilled	Hard Bristol tap	Soft Swansea tap
pH	5·7	7·8	7·0
p.p.m. Ca^{++}	—	73	7
p.p.m. Mg^{++}	—	15	0·7
0·025% *DEHS*			
Appearance	clear	slight haze	clear
Static tension (dynes cm.$^{-1}$) at 20°C	36	25–26	27–28
0·05% *DEHS*			
Appearance	clear	very turbid	slight haze
Static tension (dynes cm.$^{-1}$) at 20°C	33	25–26	25–26
0·025% *DNS*			
Appearance	clear	turbid	slight haze
Static tension (dynes cm.$^{-1}$) at 20°C	26	24–25	24–25
0·05% *DNS*			
Appearance	clear	very turbid	turbid
Static tension (dynes cm.$^{-1}$) at 20°C	25	24–25	24–25

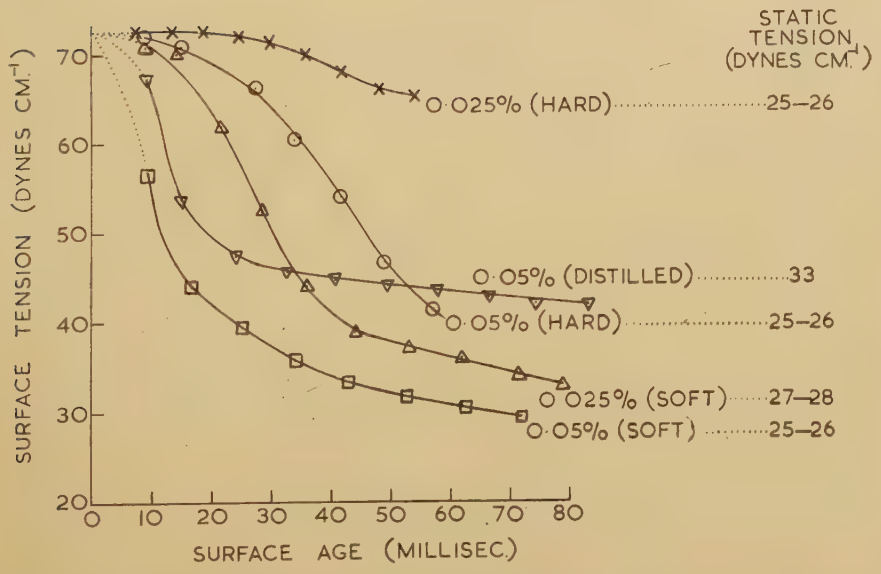

Fig. 2. Dynamic and static tensions of sodium di(2-ethylhexyl) sulphosuccinate solutions in waters of different hardness at 20°C.

In hard (Bristol) water, the situation is complicated by the occurrence of partial precipitation of the di(2-ethylhexyl) sulphosuccinate anion as the calcium (and magnesium) salt. This occurs only to a slight extent at 0·025% but more markedly at 0·05%. Consequently the 0·025% solution of DEHS in hard water is somewhat similar in ageing behaviour to 0·025% in distilled. At 0·05%, however, the sulphosuccinate ion concentration is appreciably reduced, and the initial rate of fall of tension of a newly formed surface of a solution at this concentration is slower than in distilled, despite the cation effects. The static tensions of all the tap water solutions of DEHS were within two or three dynes/cm. of each other, and were appreciably lower than the values for solutions prepared in distilled water.

DNS in tap waters (Fig. 3)

It is evident that even the smallest amounts of bivalent cations (e.g. 1 p.p.m. Ca^{++}—added as $CaCl_2$ to the solution in distilled water) reduce rather than increase the extent of the fall of tension of a newly formed surface. With increasing amounts of calcium in the water more dinonyl sulphosuccinate is precipitated, and it is noteworthy that for at least the first 50 millisec. following surface formation there is no ageing at all with 0·025% and 0·05% DNS in hard water, and with 0·025% DNS in soft water. This behaviour is attributed to the low concentration of DNS anions and the reduced calcium ion concentration remaining in solution after precipitation has occurred.

The 0·05% DNS in soft water retains sufficient dinonyl sulphosuccinate anions in solution to age at about the same rate as 0·025% DNS in distilled water.

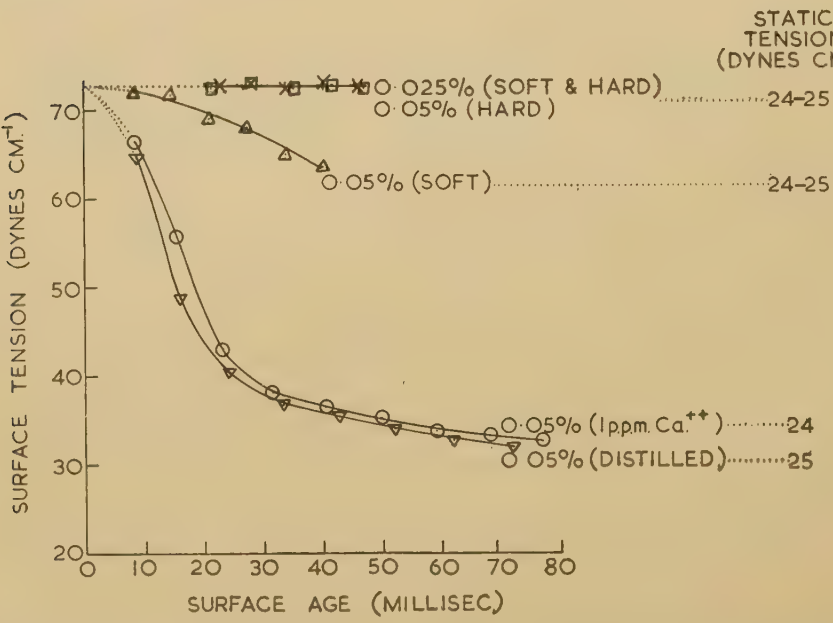

Fig. 3. Dynamic and static tensions of sodium dinonyl sulphosuccinate solutions in waters of different hardness at 20°C.

The hard water (turbid) solutions were first centrifuged to remove most of the suspended matter, but even then the ageing process could not be followed much beyond 50 millisec. because of premature break-up of the stream caused by fine particles not removed by centrifuging. For all the DNS solutions in hard and soft waters the equilibrium tensions are about 24–25 dynes/cm.—slightly lower than the corresponding values in distilled water.

Discussion.

In a consideration of surface processes involving unchanging solution-air interfaces, the use of static tension values is unlikely to give rise to erroneous conclusions. However, with surface phenomena in which either a rapid renewal of the surface, or a sudden extension in surface area, occurs—as when a small drop spreads out over a flat surface such as a leaf—static tension values may be completely misleading. In such cases the tension of the surface will fall to a value which is determined partly by the rate at which the surface is changing or enlarging and partly by the speed at which the surface active compound is adsorbed at this new interface. The more rapid or extensive the change in surface area, the more necessary is it for the surfactant to move to the surface quickly in order that it may function effectively at the new interface.

The most outstanding feature of this work is the behaviour of DNS in different waters (Fig. 3). Whilst the static tensions of all the solutions of this compound in distilled, soft and hard waters are of the same order (24–26 dynes cm. at 20°C), the rates at which these equilibrium states are approached are widely different. Thus adsorption at a newly formed solution-air interface of a 0·05% solution in distilled water occurs so rapidly that the surface tension falls to about 35 dynes/cm. within 45 millisec. of surface formation. However, at the same concentration in hard water the behaviour is quite different. 45 millisec. after a new solution-air interface is formed, the surface tension is still that of pure water, indicating that few if any of the DNS anions have reached the surface within that time. This difference is important in such processes as the determination of droplet size formed from the disintegration of fan sprays, of the further break up of the drop during its flight through the air and its subsequent fate on the leaf surface.

Nikitina and Taubman (7) in their investigations to reduce dust in coal mines by wet drilling and spraying have also shown that the true wetting properties of surface active compounds incorporated in the sprays are far better characterized in terms of their rate of surface adsorption than by their equilibrium tensions.

This work serves to emphasize again (4) the danger of assuming that results obtained for distilled water solutions may be equally valid for solutions in other waters simply because their static tensions are of the same order. The investigation is being extended to include other members of the sulphosuccinate group to determine the effect of the type and length of the hydrocarbon chain on the rate at which surface adsorption occurs. Other surface active compounds including typical cationics and nonionics will also be studied, and the results of these laboratory experiments related to the behaviour of the chemicals when used as spray adjuvants in the field.

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SPRAYING EXPERIMENTS AGAINST APPLE SCAB AND APPLE MILDEW AT LONG ASHTON, 1959-61.

By R. J. W. BYRDE, G. M. CLARKE and C. W. HARPER.

The previous paper in this series (1) recorded the promising performance of *n*-dodecylguanidine acetate (dodine acetate) against apple scab, caused by *Venturia inaequalis* (Cooke) Wint. Applied at 0·09% active material, only three times in a season favourable to scab development, the compound reduced scab on leaf and fruit by 84% and 87% respectively. Extensive trials with the compound in the U.S.A. (e.g. 2, 3) have demonstrated its value against apple scab, and there is evidence to suggest that besides a prolonged residual action it has some eradicant (4) and local systemic properties (5). On the other hand, it has sometimes been found liable to cause fruit russet (6), particularly when application coincides with night frosts. This paper is primarily concerned with further tests of the material at Long Ashton from 1959-61, three years in which the incidence of apple scab was unusually low.

Over this period, however, apple mildew, caused by *Podosphaera leucotricha* (Ell. and Everh.) Salm., has been an increasingly serious problem in many orchards, and this paper includes an account of a preliminary trial against this disease of a new material, 2-*sec.*-butyl-4,6-dinitrophenyl-3′,3′-dimethylacrylate (HOE 2784, "Morocide"). Developed in Germany, this compound showed promise against both apple mildew and red spider (7), and subsequent commercial trials in England confirmed these results (8); it was among the most successful materials in greenhouse tests at Long Ashton described elsewhere in this Report (9).

Experimental.

Fungicides. The spray materials used were as follows :

n-Dodecylguanidine acetate (dodine acetate, " Melprex ") as a commercial wettable powder containing 50% (in 1959) or 65% (in 1960 and 1961) active material.

Captan, as a commercial wettable powder containing 50% active material.

2-Heptadecylglyoxalidine acetate (glyodin) as a commercial water-miscible liquid containing 30% active material.

2-1′-Methylheptyl-4,6-dinitrophenyl crotonate (dinocap, " Karathane ") as a commercial wettable powder containing 25% active material (WP) or as a water-miscible liquid containing 50% active material (ML).

2-*sec.*-Butyl-4,6-dinitrophenyl-3′, 3′-dimethylacrylate (HOE 2784," Morocide ") as a commercial wettable powder containing 25% active material.

Wettable sulphur, as a commercial powder formulation containing 75% active ingredient.

Sprays were applied by means of a mobile machine using a triple-nozzle broom with 4/64 in. disc apertures and one short-range and two long-range swirl plates. The output was approximately 4 gal. per min. at 350 lb. per sq. in. flow pressure. Dates of application and rates are listed separately.

Methods of assessment.

Apple scab. Mean percentage areas per leaf and per fruit were estimated by Tehon and Stout's method as amplified by Marsh (10), and were normally based on samples of 250 leaves and 50 fruits per tree.

Apple mildew was estimated in 1960 on the basis of shoots of the current season's growth showing any infection. In 1961 the assessment was based on thirty shoots of 1961 growth per experimental plot, gathered at eye-level, each leaf being recorded as mildewed (even if only a trace) or healthy. Missing leaves were counted as mildewed if the axillary bud was obviously mildewed. The proportion of buds obviously mildewed on these shoots was also recorded.

Crop was recorded in lb. per tree.

Fruit colour was recorded on an arbitary scale from 0 (green) to 5 (red).

Fruit russet and cracking. In the sample of fruit taken for scab assessment the numbers of fruits showing cracking or disfiguring russet (more than 10% area) were recorded.

Notes on weather. Table I records the rainfall for the three summers. In

TABLE I.

RAINFALL (IN.) FOR SUMMER MONTHS, 1959–61.

	April	May	June	July	August	Sept.	Total
1959	2·87	1·68	1·74	3·05	1·36	0·19	10·89 (64%)
1960	1·50	1·16	2·21	4·86	4·83	4·91	19·47 (115%)
1961	3·85	1·25	1·29	2·81	3·00	2·49	14·69 (86%)
Average (1914–53)	**2·33**	**2·59**	**2·11**	**3·16**	**3·65**	**3·18**	**16·99**

general, 1959 was dry, hot and sunny, 1960 was wet, cool and dull, though April and May were dry, whilst 1961 was intermediate, resembling 1959 more

than 1960. During the 3-year period apple scab incidence was generally very low at Long Ashton, though it developed quickly in April, 1961, until halted by a dry spell starting in early May.

Results.

1959 *Trial.*

Thirty bush apple trees, variety Worcester Pearmain, spaced at 21 ft. apart in grass, were used for a comparison of two concentrations of dodine acetate, with captan included as a standard, and unsprayed control trees.

The trees had already been used in 1958, in a 6×5 Youden square layout (1). A new layout was required to eliminate the residual effects of the 1958 treatments, and a design of " Graeco-Youden " square type has been evolved which achieves this (11). There proved to be no disturbance from 1958 residuals.

Sprays were applied on 22 April, 11 May, 2 June and 30 June : this reduced schedule was aimed at making a drastic test of the fungicides. Table II

TABLE II.

1959 APPLE SCAB TRIALS : WORCESTER PEARMAIN.

Fungicide	Conc. active material (%)	Mean area scabbed (%) Leaf	Fruit
Dodine acetate	0·09	0·0035*	0·0056*
,, ,,	0·05	0·0090*	0·0152*
Captan	0·10	0·0100*	0·0030**
Control	—	0·0381	0·0555
Significant difference at 5% level (*)		0·0274	0·0365
,, ,, ,, 1% ,, (**)		0·0390	0·0520

Differences from control are indicated.

summarizes the results of leaf and fruit scab assessments carried out on 23–27 July and 17 August respectively. Largely due to the exceptionally dry season, the incidence of scab was at a very low level even on unsprayed trees.

1960 *Trials.*

Two trials were carried out in 1960, both including dodine acetate. The first was laid out in five randomized blocks on the same plot of Worcester Pearmain trees used in 1958 and 1959, each block (row of the previous layout) containing three treatments. Intermediate guard trees were used as controls. It was not thought necessary to consider residual effects of 1959 treatments, as scab incidence had been so low. Sprays were applied on 2 May, 26 May and 30 June.

The second was laid out as a 3×3 Latin square on a block of 60 Cox's Orange Pippin bush apple trees, with Worcester pollinators. Records were taken from the 3 trees at the centre of each plot, the remainder acting as guards. Sprays were applied on 22 April, 12 May, 27 May and 30 June. April and May were dry ; the incidence of scab was virtually nil, and so no scab records were taken. Table III summarizes records of red spider incidence (estimated 13 July),

TABLE III.

1960 TRIALS : WORCESTER AND COX.

Fungicide	Conc. active material	Red spider index	Fruit colour index	Fruit russet	Secondary mildew
Worcester	%			%	%
Dodine acetate	0·05	1·4*	3·3	7·6	—
Glyodin	0·075	1·2*	3·1	4·8	—
Captan	0·10	2·4	2·7	3·6	—
Control (guard trees)	—	2·2	3·1	2·8	—
Cox					
Dodine acetate	0·05	2·1	2·9	7·4	81
,, ,,	0·025	2·2	3·8	0·6	78
Captan	0·10	2·6	3·4	2·6	78

*Significantly less than value for captan (P=0·05).

and fruit colour and russet (assessed on 15 August for Worcester and 12 September for Cox). Crop weights were extremely variable and are not given. For the Cox trial the percentage of 1960 shoots with secondary mildew is included (assessed 22–23 August). Treatment effects are not significant unless so indicated.

1961 *Trials.*

(a) *Scab and mildew trial* : *Cox.* In 1961 dodine acetate (0·05%) and glyodin (0·075%) were compared with captan (0·075%) on a 3-acre orchard of Cox's Orange Pippin bush trees, planted at 24 ft. square with Laxton's Superb pollinators. Incorporated with the scab treatments on two dates were two anti-mildew fungicides, dinocap and wettable sulphur. The layout used was four replicates of a split-plot design ; whole-plots carried the three scab treatments, and each was subdivided to take the two mildew treatments. Sprays were applied on 17 April (with insecticides), 6 May, 25 May, 14 June and 29 June : the anti-mildew fungicides were included on 6 and 25 May. An acaricide was applied overall at petal-fall (3 May) and an anti-codlin spray and acaricide on 26 June with a second codlin spray on 10 July. Only two applications of anti-mildew fungicides were used, so that any effects of the scab fungicides on mildew incidence would not be masked.

Scab was assessed on spur leaves on 15–18 August ; the fruit was picked in mid-September, and samples of 50 fruits per tree were withdrawn from orchard boxes by the method of Pearce (12) for assessment of fruit scab, fruit colour and russet on 15 September. Secondary mildew incidence, on leaves and buds of 1961 shoots, was recorded on samples of 30 shoots per plot on 21–24 August. Table IV summarizes the results obtained, which are presented on the basis of both scab and mildew treatments. Owing to light blossom and some frost damage, crop was light and variable. Treatment effects are not statistically significant unless so indicated.

(b) *Mildew trial* : *Cox.* This was carried out on the block of 60 Cox's Orange Pippin trees used in 1960. The layout was again a 3×3 Latin square, balanced (as a Graeco-Latin square) for elimination of 1960 residual effects. Records were taken on the centre three trees of each plot, as in 1960.

TABLE IV.

1961 SCAB AND MILDEW TRIAL : COX.

Fungicide	Conc. active material	% Area scabbed		Mean crop	Fruit colour index	Fruits cracked or russeted	Secondary mildew	
		Leaf	Fruit				Leaves	Buds
	(%)			(lb./tree)		(%)	(%)	(%)
Scab fungicides								
Dodine acetate	0·05	0·002***	0·012	18·3	2·55	26·4	69·9	9·4
Captan	0·075	0·016**	0·015	14·2	2·62	23·2	73·2	10·2
Glyodin	0·075	0·055	0·066	14·8	2·79	29·9	69·5	10·5
Mildew fungicides								
Dinocap (ML)	0·025	0·026	0·028	15·8	2·49*	27·5	69·3*	9·4
Wettable sulphur	0·225	0·021	0·033	15·8	2·82	25·5	72·3	10·6

*Significantly less than figure for sulphur (P=0·05).
** „ „ „ „ „ glyodin (P=0·01).
*** „ „ „ „ „ „ (P=0·001).

Sprays were applied on 10 May, 24 May, 13 June, 30 June and 21 July, captan (0·1% active material) being included on all plots as a scab fungicide. Secondary mildew was recorded on 25 August and, when the fruit was picked on 21 September, records were taken of fruit colour and russet ; these are summarized in Table V. A visual estimate of red spider incidence, made on 11 July, is also included. The increased russet on control fruits is probably a reflection of red spider injury to the trees.

TABLE V.

1961 MILDEW TRIAL : COX.

Mildew fungicide	Conc. active material	Secondary mildew		Red spider index	Russet	Fruit colour index
		infected leaves	infected buds			
	(%)	(%)	(%)		(%)	
HOE 2784	0·05	69·01*	3·9**	1·67*	32·0	3·80
Dinocap (WP)	0·025	73·24*	6·2*	2·00	37·7	3·37
Control	—	82·29	17·9	3·83	63·0	3·03

*Differs significantly from control (P=0·05).
** „ „ „ „ (P=0·01).

(c) *Small-scale scab trial* : *Laxton's Superb.* A row of 12 Laxton's Superb bush apple trees which had received no scab spray before blossom was used to compare the ability of fungicides to check an established scab outbreak. The trial was laid out as 3 randomized blocks with the 3 treatments used in trial (a) above, together with an unsprayed control. At the time of the first spraying (6 May) many leaves were already heavily infected ; subsequent sprays were applied on 1 June, 22 June and 11 July.

Percentage area of leaf scab was assessed on 19 July with the following results :

Captan=0·41 ; dodine acetate=0·28 ; glyodin=0·77 ; control=0·90. Least significant difference (P=0·05)=0·28.

Because some of the trees were in their " off-season ", fruit scab could be assessed (on 19 September) on only two of the three blocks, and no statistical analysis was carried out. Mean percentage areas scabbed for the four treatments, in the same sequence as above, were : 0·72, 0·58, 0·73 and 1·22.

Note on phytotoxicity.

In the course of phytotoxicity trials on a range of varieties of apple and pear, damage followed the use of dodine acetate (0·05% active material) on six varieties of pear on 7 May, 1959. Damage took the form of leaf and fruit necrosis. The variety Conference was most severely affected, but Williams' Bon Chrétien, Laxton's Superb and Bristol Cross suffered moderate damage. Doyenné du Comice was the least damaged. This spray application coincided with a period of low night temperatures, e.g. 35°F on 5–6 May. No other damage has been encountered at Long Ashton following the use of dodine acetate.

Discussion.

Dodine acetate has now been tested against apple scab for four years at Long Ashton, and the results presented here and in the 1958 Annual Report (1) have demonstrated its value against the disease. In years such as 1959–61, when scab incidence was low or very low, its performance was not significantly better than that of captan, although in general the lowest scab figures occurred on dodine acetate plots. In a season such as 1958 at Long Ashton, in later years in other parts of the British Isles, and in the U.S.A. (3) its performance has been outstanding. While there have been reports that increased russet has followed its use (6) there is no statistical evidence that it had any adverse effect on fruit quality in the Long Ashton trials. On the other hand, although it appeared to check a light mildew attack on Worcester Pearmain in 1958 (1) and was active in a greenhouse mildew test in 1961 (9), it was virtually no better, at 0·05%, than captan against the severe mildew attacks on Cox in the 1960 and 1961 trials. There was some evidence that it checked red spider in the 1958 and 1960 trials where no specific acaricide was used. Dodine acetate is well suited for use under severe scab conditions : there is some evidence that it is able to " hold " an established attack when its local systemic properties (5) are particularly useful. Its use on pears may be inadvisable in view of the possibility of damage under cold conditions.

Glyodin was comparatively ineffective against a light scab attack in 1961 and had virtually no effect against the severe mildew attack. However, it appeared to check red spider in 1960.

The new material HOE 2784 showed some promise against mildew in its preliminary trial in 1961. Whilst not significantly better than dinocap, it was at least as good, and had no adverse effect on crop quality (cf. 8). It was used at double the concentration of dinocap to achieve this result, but a direct economic comparison cannot be made until its cost is known.

Despite the fact that five applications of either dinocap or HOE 2784 significantly reduced secondary mildew in this trial, the incidence of the disease was still very high : approximately 70% of the leaves of the current season's shoots were mildewed. It was equally clear from the 1961 scab-mildew trial that two applications of dinocap or wettable sulphur were completely inade-

quate even when supplemented by scab fungicides themselves probably capable of checking a light mildew attack. Whilst a full evaluation of the mildew results must await records of ' primary ' infection in the spring of 1962, the need for better fungicides against mildew has been demonstrated once again.

Summary.

(1) *n*-Dodecylguanidine acetate (dodine acetate) was tested against apple scab during the three seasons 1959-61. At a concentration of 0·05% active material, it significantly reduced the incidence of the disease in 1959 and 1961 ; in 1960, no scab outbreak developed. No evidence of a significant deleterious effect on fruit quality was obtained. Captan (0·1% or 0·075%) gave results of the same order, but glyodin (0·075%) was inferior in the 1961 trials.

(2) Against heavy attacks of apple mildew in 1961, dodine acetate (0·05%) and glyodin (0·075%) were not significantly better than captan (0·075%). Both reduced the incidence of red spider in 1960.

(3) Dodine acetate (0·05%) caused damage to several pear varieties when applied during a period when night temperatures were low.

(4) 2-*sec.*-Butyl-4,6-dinitrophenyl-3′,3′-dimethylacrylate (HOE 2784, " Morocide ") (0·05%) showed some promise in a preliminary trial against apple mildew, and also reduced red spider incidence without any apparent deleterious effect on fruit quality.

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POTENTIAL FUNGICIDES FOR APPLE MILDEW: PROGRESS REPORT 1961.

By R. J. W. BYRDE, MARGARET CLARKE, D. R. CLIFFORD, MARGARET MEALING and D. WOODCOCK.

The past decade has seen a marked increase in the incidence of apple mildew, caused by *Podosphaera leucotricha* (Ell. & Everh.) Salm. One contributory factor is undoubtedly the tendency of fruit growers to use organic fungicides such as captan, which exert little or no control of powdery mildews, rather than lime sulphur. This is particularly true with varieties such as Cox's Orange Pippin, which show some sensitivity to inorganic sulphur sprays. On such varieties there is thus great need for a non-phytotoxic anti-mildew agent.

Of the synthetic organic materials reported to date, 2-1′-methylheptyl-4,6-dinitrophenyl crotonate (dinocap) (1, 2) is already in widespread commercial use, despite the relatively high cost of the fairly frequent applications required (3). Other 2,4-dinitrophenyl esters have formed the basis of a recent patent (4) and one of the compounds, 2-*sec.* butyl-4,6-dinitrophenyl-3′,3′-dimethylacrylate (" Hoe 2784," "Acricid," " Morocide "), has shown some promise in field trials (5, 6, 7). In all such compounds, it is highly probable that the fungitoxicity is based on the common dinitrophenyl moiety. Thus Kirby & Frick (8, 9) found that 2-1′-methylheptyl-4,6-dinitrophenol was just as effective as an equimolar concentration of its crotonic ester, dinocap. They also demonstrated varying degrees of anti-mildew activity against *P. leucotricha* for some 2-alkyl-4,6-dinitro- and 4-alkyl-2,6-dinitrophenols, though members of the former series up to C_6 were too phytotoxic to study.

Reports of anti-mildew activity in a variety of other compounds have also appeared. 5-Acyl-8-quinolinols and their esters (10) were said to be very effective against apple mildew, albeit at the relatively high concentration of 0·2–0·5%, whilst a number of derivatives of salicylaldehyde have been found to be effective as eradicants of cucumber powdery mildew, caused by *Erysiphe cichoracearum* DC (11, 12). Rossi and Corradini (13) claimed high fungicidal

activity for dimethyldithiocarbamylcarbinyl benzoate against powdery mildew of tobacco, whilst salts of diformamidine di- and mono-sulphides have been reported active against *P. leucotricha* (14). Derivatives of 2,3-dimercaptoquinoxaline, e.g. quinoxaline-2,3-diyl-trithiocarbonate or thioquinox (" Eradex ") form yet another group of organo-sulphur compounds for which activity against powdery mildews has been claimed (15, 16).

Several organophosphorus derivatives have recently been shown to have high activity against powdery mildews. Of these, 3-phenyl-5-amino-1-[bis-(dimethylamido) phosphoryl]-1,2,4-triazole (" Wepsyn ") (17), for which systemic properties have been claimed, appears to have the same order of performance as dinocap (3, 18, 19).

Sprague (20), in a survey of potential materials for control of apple mildew, found that a polypeptide antibiotic (" Phytopabst "), a copper hydroxide complex (" DY-Q-Plex-1 ") and 2-amino-3-chloro-1,4-naphthaquinone (" 06K-50W ") were promising materials, but dodine acetate was only weakly active (cf. 7, 9, 20). Another antifungal antibiotic, Venturicidin, has recently been reported (21) to have some activity against *P. leucotricha* at 20–40 μg/ml. Subsequent to the discovery of the acaricidal properties of polybutenes, Fisher (22) demonstrated their activity against powdery mildew of rose and they have also been found effective against apple mildew in the field (23).

This communication reports the results of preliminary tests with three main groups of compounds. The first, comprising nitrophenyl and nitronaphthyl derivatives, was of interest because of structural similarities to dinocap (Tables I and II). The second included materials, other than dinitrophenyl derivatives, already known to possess some activity against powdery mildews (Table IIIa). A third miscellaneous group contained compounds of known or of potentially high activity against other fungi, but apparently not previously tested against *P. leucotricha*. Three *n*-alkyl salicylic acids were also included here, in view of the known uncoupling action of both 2,4-dinitrophenol and salicylic acid (24) (Tables IIIb and IV).

Materials.

Mono- and dinitrophenol derivatives are summarized in Table I, analytical details being given for all new compounds. Härtel (5) mentions 2-*sec.* butyl-4,6-dinitrophenyl benzoate but quotes neither m.p. nor analysis.

Derivatives of 1-*naphthol* are summarized in Table II, analytical details being given for the new compounds.

n-*Alkylguanidine acetates* were prepared as already described by Byrde, Clifford and Woodcock (27).

Dimethyldithiocarbamylcarbinyl acetate and *benzoate* and *zinc dithiobenzoate* were kindly supplied by Robinson Bros., West Bromwich.

Propamidine acetate was prepared by the method of Taylor and Ehrhart (28) using ethyl orthopropionate, and crystallized from ethyl alcohol-ether. It had m.p. 169–170° (Found : N, 21·1. $C_5H_{12}O_2N_2$ requires N, 21·2%).

Lauramidine hydrochloride was prepared via the corresponding nitrile and amidoxime, by the method of Eitner & Wetz (29). It crystallized from acetone, and had m.p. 127·5–128·5° (Found : N, 11·55. Calc. for $C_{12}H_{37}N_2Cl$: N, 11·45%). Eitner & Wetz (29) give m.p. 128–129°.

n-*Decylamine*, prepared in 80% yield from undecylic acid using the Schmidt

reaction, was treated in ethereal solution with dry gaseous hydrogen chloride to form the *hydrochloride* m.p. 193–194°. Komppa & Talvitie (30) give m.p. 194°.

5-n-*Alkyl salicylic acids* were obtained from the Chemical Research Laboratory, Teddington.

2,2,3-*Trichlorobutyraldehyde* 2,4-*dinitrophenyl hydrazone.* The parent aldehyde (" butyl chloral ") was a gift from Westvaco Chlorine Products Corp., U.S.A. ; the 2,4-dinitrophenylhydrazone crystallized from ether-light petroleum (b.p. 60–80°) in rosettes of small yellow prisms m.p. 131–132° (Found : N, 15·3. $C_{10}H_9O_4N_4Cl_3$ requires N, 15·7%).

sym-*Dichloracetone*-2,4-*dinitrophenylhydrazone.* This compound is claimed by Johnson (31) (m.p. 132–3° ; Found : N, 11·73. $C_9H_8O_4N_4Cl_2$ requires N, 11·81%). We find m.p. 130–131° (Found : N, 18·0 $C_9H_8O_4N_4Cl_2$ requires N, 18·25%).

Methods.

Compounds under test were formulated in one of four ways :—

(a) By dissolving in solvent naphtha containing 4% (w/v) of the emulsifying agent " CPGE 6." The naphtha solution was then diluted with water to give an emulsion with final naphtha concentration 0·1% (v/v).

(b) By dissolving in ethanol, then diluting 100-fold with water.

(c) The 2,4-dinitrophenylhydrazones were insoluble in both solvent naphtha and ethanol and were ground up with sodium carboxymethylcellulose (Na CMC) solution, then diluted with water. The final Na CMC concentration was 0·025% (w/v).

(d) One compound, zinc dithiobenzoate, was supplied and used as a 70% wettable powder.

In all cases the wetting agent " Ethylan CP " was incorporated at a final concentration of 0·025% (v/v). Appropriate formulation blanks were included in each test together with untreated controls.

Seedlings of the cider apple varieties Tremlett's Bitter and Knotted Kernel, grown in 3″ pots and about 4″ high, were used for the tests, with normally eight replicates per treatment. Plants with appreciable mildew already present were rejected. The uppermost fully expanded leaf was notched and the seedlings dipped into the test formulations. When dry they were placed in randomized blocks in a greenhouse compartment. Under these conditions extensive " natural " mildew infections readily developed on untreated plants. About two weeks after the fungicide treatment, the top surface of the notched leaf and those leaves immediately above and below were examined and an estimate made of the percentage area mildewed for each leaf. For statistical analysis an angular transformation was used.

Phytotoxicity, where apparent as leaf flecking or scorching, was recorded on an arbitrary scale from 0 (nil) to 4 (severe).

Results.

The results of tests against apple mildew are shown on the right in Tables I–IV, the percentage reduction in mildew being calculated on the basis of the value for the appropriate formulation blank. Where phytotoxicity was encountered it is also recorded in the tables.

TABLE I.

MONO- AND DINITROPHENOL DERIVATIVES.

Compound	m.p. or b.p.	Solvent	Reference or Analysis						% Mildew reduction at 5×10^{-4} M			Phyto-toxicity index
									Test 1	*Test* 2	*Test* 3	
2-1′-Methylheptyl-4,6-dinitrophenyl crotonate	134–138°/0·01 mm.	—	Clarke & Woodcock (25)						—	55*	—	0·0
,, ,, butyrate	168–172°/0·005 mm.	—	,,			,,		,,	—	55*	—	0·0
2,4-Dinitro-6-1′-propylpentylphenyl crotonate	180–190°/0·02 mm.	—	,,			,,		,,	—	21	—	0·0
,, ,, butyrate	156–160°/0·004 mm.	—	,,			,,		,,	—	43	—	0·0
2-*sec.*Butyl-4,6-dinitrophenyl-3′,3′-dimethylacrylate	65·5°	P	Kindly supplied by Boots Pure Drug Co.						—	61**	43	0·0
			Found %			*Required* %						
			C	H	N	C	H	N				
+ ,, ,, benzoate	71–72·5°	P	59·1	4·8	8·2	59·3	4·65	8·1	—	—	19	0·0
+ ,, ,, *p*-chlorobenzoate	99–100°	aq. MeOH	53·8	4·0	7·1	53·9	4·0	7·4	—	—	0	0·0
+2,4-Dinitrophenyl cinnamate	127·5–129°	aq. Acetone	56·9	3·1	9·2	57·3	3·2	8·9	—	34	—	0·0
+2-Nitrophenyl cinnamate	82·5–84°	aq. MeOH	66·7	4·0	5·1	66·9	4·1	5·2	—	2	—	0·0
+4-Nitrophenyl crotonate	104·5–105·5°	MeOH	58·3	4·4	6·7	58·0	4·4	6·8	—	24	—	0·0
+2-Nitrophenyl crotonate	138–140°/1·5 mm.	—	—	—	6·6	—	—	6·8	—	6	—	0·0
+2-Nitrophenyl butyrate	A	—	—	—	6·7	—	—	6·7	—	12	—	0·0
+2,4-Dinitrophenyl butyrate	35–35·5°	aq. MeOH	47·25	3·95	10·7	47·25	3·95	11·0	0	—	—	1·0***
+ ,, ,, crotonate	79–79·5°	aq. MeOH	47·8	3·1	11·3	47·6	3·2	11·1	0	—	—	0·8***
+2,4-Dinitrophenyl 6-methylphenyl butyrate	49–50°	P	49·5	4·4	10·4	49·3	4·5	10·45	22	—	—	1·0***
Technical dinocap (5×10^{-4} *M*) (*for comparison*):									*89***	*70***	*61*	*0·0*

+=New compound. A=Purified by elution from alumina column. P=light petroleum (b.p. 40–60°).
*Difference from formulation blank significant at 5% ; ** at 1·0% ; *** at 0·1% level.

TABLE II.

DERIVATIVES OF 1-NAPHTHOL.

Compound	Substituent	m.p. or b.p.	Solvent	Reference or Analysis						% Reduction in mildew at 5×10^{-4} M	Phytotoxicity index
—	2,4-NO_2	137–138°	—	Purchased from B.D.H. Ltd.						83***	1·1***
Benzoate	,,	176·5–178°	BP	Zincke & Krollpfeiffer (26) give 174°						0	0·0
+Methyl ether	2-*n*-hexyl-4-NO_2	A	—	Clarke & Woodcock (unpub.)						15	0·0
				Found %			*Required* %				
				C	H	N	C	H	N		
+Crotonate	2,4-NO_2	132·5–133°	aq. MeOH	55·8	3·5	9·6	55·65	3·3	9·3	10	0·0
+Butyrate	,,	82·5–83·5°	MeOH	55·0	4·0	9·3	55·3	3·95	9·2	25*	0·2
+Crotonate	4-NO_2	110·5–111·5°	EP	65·0	4·25	5·1	65·35	4·3	5·45	48***	0·5*
+Butyrate	,,	47–48·5°	P	64·9	5·1	5·5	64·9	5·0	5·4	41***	1·0***
+Crotonate	2-NO_2	A	—	—	—	5·5	—	—	5·45	30**	0·0
+Butyrate	,,	A	—	—	—	5·8	—	—	5·4	15	0·0
+Hexoate	4-NO_2	A	—	—	—	4·4	—	—	4·9	21	0·1
										*79****	*0·0*
										Dinocap (for comparison):	

+=New compound. A=Purified by elution from alumina column. BP=Benzene-light petroleum (b.p. 40–60°).
EP=Ether-light petroleum (b.p. 40–60°). P=Light petroleum (b.p. 40–60°).
*Difference from formulation blank significant at 5% ; ** at 1·0% ; *** at 0·1% level.

TABLE III.

POTENTIAL ANTI-MILDEW AGENTS.

Compound	m.p.	% Mildew reduction at 10^{-3} M	
(a) *Substituted guanidines and dithiocarbamates*		*Test* 1	*Test* 2
n-Hexylguanidine acetate	139–140°	37*	—
n-Nonyl „ „	126–127°	51***	—
n-Dodecyl „ „	132–133°	55***	—
n-Pentadecyl „	131–132°	17	—
n-Octadecyl „	123–124°	3	—
Dimethyldithiocarbamylcarbinyl benzoate	—	—	4
„ „ „ acetate	—	—	4
(b) *Other potential agents*			
+Propamidine acetate	169–170°	—	0
Lauramidine hydrochloride	127·5–128·5°	—	0
Decylamine hydrochloride	193–194°	—	22
Zinc dithiobenzoate	—	—	0
5-*n*-Propylsalicylic acid	98–100°	19	—
5-*n*-Hexyl „ „	77–78°	25	—
5-*n*-Nonyl „ „	69–71°	20	—
Dinocap (5×10^{-4} M) *for comparison*		*80***	*61*

+New compound.
*Difference from formulation blank significant at 5% ; *** at 0·1% level.

TABLE IV.

2,4-DINITROPHENYLHYDRAZONES.

Carbonyl compound	m.p.	% Mildew reduction at 10^{-3} M
+Butyl chloral	131–2°	0
+*sym*-Dichloroacetone	130–131°	0
Formaldehyde	164–165°	8
4-Chloroacetophenone	232–233°	0
Methyl glyoxylate	145–146°	16
o-Chlorobenzaldehyde	206°	0
o-Hydroxyvalerophenone	278–279°	21
o-Hydroxycapriphenone	84–85°	0
Chloroglyoxal	289°	15
Dinocap (5×10^{-4} *M*) *for comparison*		*42***

+New compound. **Difference from formulation blank significant at 1·0% level.

Discussion.

Amongst the compounds showing high anti-mildew activity, the esters of 2-*sec*.butyl- and 2-1′-methylheptyl-4,6-dinitrophenols were most interesting. Despite the well-known phytotoxicity of the former phenol (dinoseb) all three esters tested were non-damaging (cf. 32, 33) though of these only the 3′,3′-dimethylacrylate (" Morocide ") was effective against apple mildew, being of comparable activity to the butyrate and crotonate of the latter phenol. By contrast, the corresponding esters of the isomeric 2,4-dinitro-6-1′-propylpentylphenol were considerably less active. The only other highly active compound, 2,4-dinitro-1-naphthol, showed slight phytotoxicity. This could be virtually eliminated by esterification, but the crotonic and butyric esters were consider-

ably less effective and also inferior to the corresponding esters of 4-nitro-1-naphthol.

Of the *n*-alkyl guanidine acetates tested, whilst the nonyl and dodecyl members reduced the incidence of mildew by approximately 50% (cf. 9), the latter compound (dodine acetate) is known to be relatively inactive in field tests (cf. 7, 9, 20).

The remaining compounds showed no significant control of apple mildew, although several are known to be highly toxic to other groups of plant pathogenic fungi. Thus the 2,4-dinitrophenylhydrazones were all ineffective, although some of these compounds show high activity against conidia of *Monilinia fructicola* (34) and we have also found high activity against conidia of *Venturia inaequalis*. This again emphasizes the anomalous position occupied by powdery mildews in crop protection problems. It is perhaps significant that many compounds active against this fungal group also possess acaricidal properties.

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BLACK CURRANT LEAF SPOT: SPRAY TRIAL 1959-61.

By A. T. K. CORKE.

Previous work at Long Ashton has shown that the discharge of ascospores of *Pseudopeziza ribis* Kleb., from overwintered black currant leaves, can be effectively prevented in laboratory trials by treatment with a number of fungicidal materials at reasonably low concentrations (2). In field experiments, the difficulty of achieving adequate cover, combined with the rapid spread of the disease in the spring after infection by airborne ascospores from unsprayed leaves, made it difficult to estimate the value of this control measure. Therefore, when a suitable black currant plantation became available at the Efford Experimental Horticulture Station, two materials, whose use is permitted on black currants before harvest, were chosen for comparison at equal strengths by weight. The effects of spraying at intervals before and after harvest, over a period of three years, are given below.

Experimental.

The trial was carried out on a plantation of alternate rows of Baldwin and Mendip Cross, planted in 1953 at 1420 bushes per acre in 12 rows 8 ft. apart and 120 bushes long. The bushes were divided for experimental purposes into 3 blocks of 12 plots, each plot consisting of 10 bushes of each variety, with a row of guard bushes on either side. By leaving the guard rows unsprayed, and one guard bush at either end of each row, adjacent plots of treated bushes were separated by 2 bushes in every direction, and exposed on one side to uncontrolled infection.

Materials.

Two spray materials were applied at rates giving approximately the same weight of active ingredient :

(a) Captan at 2 lb. of 50 per cent wettable powder per 100 gallons of water.
(b) Zineb at 1½ lb. of 65 per cent wettable powder per 100 gallons of water.

The sprays were applied by hand-lance to give as good an underleaf cover as possible with 300 gallons of spray per acre, according to the schedule below.

No treatment.
Captan (i) .... Mid-May and mid-June pre-harvest sprays.
,, (ii) .... July/August and mid-September post-harvest sprays.
Zineb (i) .... Mid-May and mid-June pre-harvest sprays.
,, (ii) .... July/August and mid-September post-harvest sprays.
,, (iii) .... Pre- and post-harvest sprays (i) and (ii).

The dates of the spray applications and picking are given in Table I in relation to the time of appearance of leaf spot during the years 1959–61.

The percentage leaf spot infection was assessed at regular intervals, from the first appearance of the disease until defoliation was complete, using the method of Clarke and Corke (1) ; the weight of the crop harvested from each variety in each plot was also recorded. Infected leaves from each variety in

TABLE I.

DATES OF SPRAY APPLICATIONS, HARVEST AND APPEARANCE OF LEAF SPOT, 1959–61.

	1959	1960	1961
Pre-harvest sprays	25 May 16 June	16 May 16 June	18 May 13 June
Post-harvest sprays	29 July 14 Sept.	26 July 8 Sept.	16 August 12 Sept.
Harvest			
Mendip Cross ..	29 June	4–6 July	28 June
Baldwin	9 July	19–20 July	7–9 July
Leaf-spot			
First record ..	25 June	30 May	26 April
First assessment ..	21 July	4 July	9 May

each of the treated plots of bushes were gathered in the autumn for overwintering on the site, or at Long Ashton. These leaves were examined in the following spring, using a method already described (2), to obtain a value for the intensity of ascospore discharge. The freshly-collected leaves showed such large differences between treatments that, at the time of selecting the discs for the discharge experiments, they were scored for the abundance of mature apothecia. These scores, with those obtained for the intensity of discharge, were used to give a measure of the inoculum potential on leaves from bushes given different treatments in the previous year. The maximum score possible was 60.

Results.

It can be seen from Table I that although the crop was picked 1–2 weeks later in 1960 than in the other two years, leaf spot, which was first seen just before the harvest of Mendip Cross in 1959, appeared nearly 4 weeks earlier in 1960, and 8 weeks earlier in 1961, 5 and 8 weeks before harvest respectively. Despite these seasonal variations in the development of the disease, spray applications were made on similar dates each year, with the exception of the first post-harvest spray. Although in 1959 the first spray was delayed by bad weather, both pre-harvest sprays were applied before leaf spot was detected : in 1960, only the first spray preceded the appearance of leaf spot, while in 1961 leaf spot appeared 3 weeks before this spray was applied.

In order to examine more fully the effects of the treatments on leaf spot and on the crop produced, the two varieties are considered separately below.

Mendip Cross.

The percentage infection on treated and untreated bushes on the dates when assessments were made is given with the appropriate levels of significance in Table II. Although towards the end of the summer of 1959 infection on all the treated bushes was significantly lower than that on the untreated bushes, the pre-harvest and the combined pre- and post-harvest sprays with zineb were the most effective throughout the season, closely followed by the pre-harvest treatment with captan. These three treatments were again effective in 1961, but in 1960 only the two zineb treatments had any effect. It would appear

TABLE II.

PERCENTAGE INFECTION ON TREATED AND UNTREATED BUSHES.

VARIETY : MENDIP CROSS

Date of assessment

1959	21 July	7 Aug.	18 Aug.	3 Sept.	21 Sept.	5 Oct.	12 Oct.	
Untreated	1·9	7·4	13·4	44·8	67·1	90·8	100·0	
Captan (i)	0	1·2**	1·2**	13·4**	32·9**	53·5**	57·0***	
,, (ii)	1·2	7·4	7·4	21·1*	30·7**	43·9***	41·3***	
Zineb (i)	0·7	0***	0***	5·0***	10·2***	27·3***	35·4***	
,, (ii)	0	2·8*	2·8*	5·0***	13·4***	21·8***	19·9***	
,, (iii)	0	0·7***	1·2**	5·0***	5·1***	7·4***	10·0***	
1960	**4 July**	**14 July**	**26 July**	**8 Aug.**	**18 Aug.**	**30 Aug.**	**13 Sept.**	
Untreated	5·0	5·0	13·4	29·7	46·5	70·0	95·0	
Captan (i)	2·8	5·0	13·4	23·3	36·5	60·8	83·5	
,, (ii)	3·9	5·0	13·4	32·4	50·9	67·5	86·4	
Zineb (i)	5·0	5·0	5·0*	10·2*	32·1	46·7*	70·3*	
,, (ii)	5·0	5·0	7·4	32·1	43·0	60·0	80·0	
,, (iii)	5·0	5·0	10·2	17·2	32·9	44·2*	63·8**	
1961	**9 May**	**2 June**	**16 June**	**5 July**	**25 July**	**15 Aug.**	**18 Sept.**	**10 Oct.**
Untreated	5·0	5·0	13·4	35·0	40·0	80·0	95·0	95·0
Captan (i)	5·0	5·0	5·0**	25·0**	30·0*	60·0***	79·4***	95·0
,, (ii)	5·0	5·0	10·3	27·5*	37·5	76·7	93·1	95·0
Zineb (i)	5·0	5·0	7·4*	25·0**	25·0**	40·0***	63·8***	93·1
,, (ii)	5·0	5·0	5·0**	25·0**	43·3	80·0	90·8	95·0
,, (iii)	5·0	5·0	5·0**	25·0**	25·0**	53·3***	63·8***	79·8***

VARIETY : BALDWIN

1959	21 July	7 Aug.	18 Aug.	3 Sept.	21 Sept.	5 Oct.	12 Oct.	
Untreated	1·9	16·8	30·5	65·2	83·0	95·0	100·0	
Captan (i)	0·7	1·2**	2·8**	13·6***	33·2***	58·4**	74·2**	
,, (ii)	1·9	14·8	25·3	39·0*	45·9**	63·2**	51·8***	
Zineb (i)	1·2	1·2**	2·8**	7·4***	10·2***	34·6***	47·4***	
,, (ii)	3·9	15·3	26·3	34·0**	45·6**	61·3**	28·9***	
,, (iii)	0	1·2**	1·2**	2·8***	1·2***	10·2***	11·1***	
1960	**4 July**	**14 July**	**26 July**	**8 Aug.**	**18 Aug.**	**30 Aug.**	**13 Sept.**	
Untreated	7·4	15·3	35·4	57·0	80·3	95·0	95·0	
Captan (i)	3·9	10·2	21·1	28·6*	62·1	83·9	91·1	
,, (ii)	5·0	20·9	29·9	45·9	71·7	86·4	91·1	
Zineb (i)	5·0	5·0	5·0**	13·4***	34·6**	57·8**	91·1	
,, (ii)	5·0	7·4	23·0	40·5	60·0	83·0	95·0	
,, (iii)	10·2	13·6	13·6*	24·0**	43·0*	50·9**	77·5**	
1961	**9 May**	**2 June**	**16 June**	**5 July**	**25 July**	**15 Aug.**	**18 Sept.**	**10 Oct.**
Untreated	5·0	20·9	24·2	47·5	60·0	95·0	95·0	95·0
Captan (i)	5·0	16·9	27·5	35·0	43·3*	63·8**	95·0	95·0
,, (ii)	5·0	13·4	27·5	41·7	53·3	88·3	95·0	95·0
Zineb (i)	5·0	20·9	24·2	32·5	43·3*	50·0***	79·4***	95·0
,, (ii)	5·0	10·1	25·0	43·3	56·7	88·3	95·0	95·0
,, (iii)	5·0	25·0	25·0	32·5	40·0**	57·0***	85·6***	95·0

* Significantly less than untreated bushes at 5 per cent ;
** at 1 per cent ; *** at 0.1 per cent level.

from these results that the post-harvest sprays were of little value in reducing leaf spot infection in the same year. While this was certainly true in 1960 and 1961, it was not the case in 1959. In Table III, the differences in percentage

TABLE III.

EFFECT OF SPRAY TREATMENTS ON RATE OF INFECTION BY *P. RIBIS*.

Mendip Cross	1959		1960		1961		Means 1959–61	
	(a)†	(b)††	(a)	(b)	(a)	(b)	(a)	(b)
Untreated . .	7 Sept.	7 Oct.	20 Aug.	13 Sept.	31 July	18 Sept.	19 Aug.	23 Sept.
	Days	Per cent	Days	Per cent	Days	Per cent	Days	Per cent
Captan (i) . .	26	54	5	84	8	79	13	72
,, (ii) . .	—	45	—2	86	1	93	0	75
Zineb (i) . .	—	29	12	70	30	64	21	54
,, (ii) . .	—	23	3	79	—2	91	½	64
,, (iii) . .	—	8	15	64	13	64	14	45

Baldwin	1959		1960		1961		Means 1959–61	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Untreated . .	27 Aug.	5 Oct.	4 Aug.	30 Aug.	9 July	15 Aug.	3 Aug.	6 Sept.
	Days	Per cent	Days	Per cent	Days	Per cent	Days	Per cent
Captan (i) . .	35	59	11	84	23	64	23	69
,, (ii) . .	28	63	6	86	11	88	15	79
Zineb (i) . .	—	35	22	58	37	50	30	48
,, (ii) . .	29	61	9	83	6	88	14	77
,, (iii) . .	—	10	25	51	29	57	27	39

† (a) Date on which infection on untreated bushes reached 50 per cent, and interval (in days) before infection reached this level on treated bushes.

†† (b) Date on which infection on untreated bushes reached 95 per cent, and percentage infection on treated bushes at this time.

infection given above have been translated into the effect of the treatments on the rate of infection. For each year, the extra time (days) needed for leaf spot infection on treated bushes to reach 50 per cent compared with the date on which it reached this level on the untreated bushes, is given in Column (a); the date on which infection reached 95 per cent on the untreated bushes, and the percentage infection on the treated bushes at this time, are given in Column (b). It can be seen that the progressively earlier appearance of leaf spot each year from 1959 to 1961 was reflected in the dates at which the untreated bushes became 50 per cent infected, but while infection reached 95 per cent after the same length of time in the first two years, it took 5 weeks longer on this variety in 1961. In none of the three years did leaf spot infection exceed 50 per cent on unsprayed plots before the crop was picked, and the relatively poor results achieved by the post-harvest sprays in 1959, when leaf spot development was late, and the superiority of the pre-harvest sprays in all three years, stressed the importance of early spraying in the effective reduction of leaf spot. In

general, the post-harvest sprays came too late to have much effect on leaf spot infection during the rest of the season, although post-harvest zineb occasionally reduced leaf spot slightly and more than captan applied at the same time. By delaying the early development of leaf spot by 2–3 weeks and reducing infection by up to 50 per cent over the three years of the trial, the early zineb sprays had a marked beneficial effect in very different seasons.

When the effect of the summer spray treatments on the overwintering leaf infections was examined, observations made in the following spring indicated that the early sprays were less effective than the late sprays in preventing the development of apothecia : leaves from bushes given post-harvest sprays would therefore be likely to contribute less ascospore inoculum for primary infections than those from bushes given only pre-harvest sprays, or none at all. The figures obtained as a measure of the potential (ascospore) inoculum present on treated and untreated leaves are given in Table IV, with the mean values for

TABLE IV.

INOCULUM (ASCOSPORE) POTENTIAL ON OVERWINTERED LEAVES GATHERED FROM BUSHES GIVEN DIFFERENT SPRAY TREATMENTS.

(Highest possible score 60)

	1959–60 Gathered 4 November and overwintered at Long Ashton	1960–61 Gathered 6 October and overwintered at Efford	Mean
Mendip Cross			
Untreated ..	51·5	8·2	29·9
Captan (i) ..	30·2	1·8	16·0
,, (ii) ..	16·3	3·5	9·9
Zineb (i) ..	35·6	0·9	18·3
,, (ii) ..	0·1	1·0	0·6
,, (iii) ..	1·3	0·8	1·1
Baldwin			
Untreated ..	45·5	6·4	26·0
Captan (i) ..	28·5	3·8	16·2
,, (ii) ..	41·5	5·1	23·3
Zineb (i) ..	12·5	1·0	6·8
,, (ii) ..	6·2	3·6	4·9
,, (iii) ..	0·2	1·5	0·9

the winters of 1959–60 and 1960–61. In 1960 and 1961, the seasons in which post-harvest sprays could have affected the primary infections, the development of leaf spot infection on bushes given post-harvest treatments was slower than on the unsprayed bushes until mid-July : in 1961 the percentage infection was still significantly less than on the untreated bushes at this time.

Since only three treatments were applied before harvest in 1959, the crop weights were examined on this basis, but no consistent effect of either pre-harvest captan or zineb was found. In 1960 and 1961 the possibility of residual effects from the previous year's treatments was an additional factor. The mean crop weights (lb. per block) picked annually from the treated plots, and the mean crop (cwt. per acre at 1420 bushes per acre) for 1960–61 are given in Table V. In 1960–61 the crops picked from bushes given the pre-harvest and

TABLE V.

CROP HARVESTED EACH YEAR PER BLOCK (16 BUSHES) PER TREATMENT.

	1959	1960		1961		Mean 1960–61	
Treatment	Crop (lb.)	Treatment	Crop (lb.)	Treatment	Crop (lb.)	Treatment	Crop (cwt./acre)
Mendip Cross							
None	89·1	None	105·5	None	112·5	None	86·4
Captan (ii)		Zineb (ii)	112·7	Captan (i)	115·6	Captan (i)	92·7
Zineb (ii)		Captan (i)	118·5	Captan (ii)	119·1	Zineb (ii)	94·3
Captan (i)	89·7	Captan (ii)	123·8	Zineb (ii)	125·4	Captan (ii)	96·1
Zineb (i)	82·3	Zineb (iii)	124·0	Zineb (i)	126·0	Zineb (i)	99·5*
Zineb (iii)		Zineb (i)	125·1*	Zineb (iii)	133·7*	Zineb (iii)	102·1*
Baldwin							
None	99·5	None	94·4	Zineb (ii)	94·1	None	74·7
Captan (ii)		Zineb (ii)	106·2	None	94·3	Zineb (ii)	79·3
Zineb (ii)		Captan (i)	114·1	Captan (ii)	98·5	Captan (i)	84·6
Captan (i)	86·4*	Captan (ii)	118·1	Captan (i)	99·4	Captan (ii)	85·8
Zineb (i)	96·6	Zineb (i)	129·4**	Zineb (i)	116·0	Zineb (i)	97·2*
Zineb (iii)		Zineb (iii)	137·4**	Zineb (iii)	128·7*	Zineb (iii)	105·4**

* Significantly different from crop from untreated bushes at 5 per cent ; ** at 1 per cent level.

the pre- and post-harvest zineb sprays were the heaviest, and although from the remaining treatments the crops were all heavier than those from untreated bushes, post-harvest captan and zineb in the previous year tended to have more effect on crop weights than pre-harvest captan in the current year, particularly on Mendip Cross.

Baldwin.

In general, this variety differed from Mendip Cross in its reaction to the factors affecting the rate of increase of leaf spot. Apart from a progressively earlier development, infection reached the 95 per cent level earlier than on Mendip Cross by a greater margin each year. In 1959 the effects of treatments, particularly of post-harvest zineb, appeared to be rather less than on Mendip Cross, but in 1960 the pre-harvest zineb treatments were more effective than on Mendip Cross (Table II). This can be seen more clearly in Table III (Column (a)) where in 1960 the delay imposed on leaf spot development by all the sprays is from 6 to 10 days longer on Baldwin than on Mendip Cross, and the eventual infection (Column (b)) is 12 per cent less on the plots given pre-harvest zineb sprays. Similarly in 1961 the delay in development on Baldwin is 7–16 days greater, and the eventual infection generally less than on Mendip Cross. Although infection reached 95 per cent earlier on unsprayed Baldwin than on Mendip Cross bushes, the rate at which infection increased on plots given the pre-harvest sprays was very similar in each year. Thus, in spite of differences in percentage infection at levels of significance which would suggest that leaf spot was reduced more on Mendip Cross than on Baldwin bushes, the latter benefited to a greater extent from the spray treatments. The post-harvest sprays on this variety gave a mean delay of 2 weeks in 1960 in reaching the 50 per cent infection level, and 8–10 days in 1961, when infection on the unsprayed bushes reached this level at harvest, 5 weeks before the first post-harvest spray

was applied. This delay could be attributed to a low level of inoculum from which the primary infections took place, and it can be seen from Table IV that although not as great as on Mendip Cross, a difference in inoculum level existed at least between the leaves given post-harvest zineb and the untreated leaves.

On the crops harvested from the treated Baldwin plots, the effects of the treatments were generally greater than on Mendip Cross, but particularly on the plots given pre-harvest zineb (Table V) ; of the post-harvest treatments, captan appeared to be slightly superior to zineb, as with Mendip Cross.

Effects of rainfall.

Since the minimum time needed, under favourable conditions, for completion of the cycle from infection to re-infection is about 10 days, and the spread of infection once the primary (ascospore) infection has taken place is by means of rain-carried conidia, the rate at which leaf spot infection increases is governed by the frequency with which rain falls and, to some extent, by the amount which falls.

The rate of increase in infection on unsprayed bushes was very similar in the first two years of the trial, although more than twice as much rain fell in 1959 as in 1960, in the period between the first pre-harvest spray and the final assessment of leaf spot infection. Six inches of rain fell on 28 days during this period in 1959, with 5 intervals of more than 10 days of dry weather between spells of wet weather ; in the following year there were 14″ rain on 49 days, and only 2 intervals of 10 or more dry days. In 1961, 6″ rain fell on 46 days during which there were few falls of more than 0·2″, and 3 periods of 10 or more dry days.

The maximum rate of increase in percentage infection recorded during this trial was in 1959 when, between 18th August and 13th September, leaf spot on Baldwin increased by 35·7 per cent (2·2 per cent per day) : the increase on Mendip Cross during the same period was 31·4 per cent (2·0 per cent per day). There was little difference between the maximum rates of increase in the years of the trial, that on Baldwin being 1·7 per cent per day in both 1960 and 1961, while on Mendip Cross it was 1·8 and 1·9 per cent per day respectively. Assuming that the periods when the maximum rate of increase occurred were those most favourable for the spread of infection, it appears that a rate of about 2 per cent per day represents the highest rate likely to be encountered in most seasons.

Leaf spot infection appeared at an earlier date each year, altering the relationship between disease incidence and the fixed spray schedule in each season. In 1959, when 1·29″ rain fell on 11th July, 25 days after the second pre-harvest spray had been applied, leaf spot, which had been present on the bushes since 25th June, increased on the unsprayed Baldwin bushes to 17 per cent infection by 7th August (a rate of 0·9 per cent per day), but was still less than 2 per cent on all those given the pre-harvest sprays. In 1961, when leaf spot infection had reached 24 per cent on all the Baldwin plots when the second pre-harvest spray was applied, the rate of increase was slower on the treated plots than on those still untreated, but became greater after 1·65″ of rain had fallen. Although the second post-harvest spray generally came too late to have much effect on the rate of infection, the earlier one reduced it slightly until wet weather again caused an increase. In 1960 this occurred immediately after

spraying, but some effect on the rate of leaf spot infection was achieved in the other years. This did not appear to be true of the bushes receiving only pre-harvest sprays, which tended to show a greater increase in infection after the same periods of rain. Comparing the materials used, the effect on leaf spot infection of spraying with zineb was of rather longer duration than that obtained with captan.

Discussion.

No explanation can at present be offered for the appearance of leaf spot at an earlier date in each year of the trial, but because of this variation results obtained from a pre-determined spray programme give a better assessment of the effects of the sprays than was foreseen. Although leaf spot develops more slowly on Mendip Cross than on Baldwin (3) and the weather in the three years of the trial was quite different, several generalizations about the effects of the treatments can be made. Pre-harvest spraying with zineb was superior to captan in reducing leaf spot infection, in the duration of its effect in the current year, and in increasing the crop harvested in the following year. Post-harvest zineb, on the other hand, was not clearly better than captan in its effect on infection, and was slightly less beneficial in its effect on the weight of the following year's crop. However, it was abundantly clear that the post-harvest sprays were of little value compared with the pre-harvest ones.

The relative ineffectiveness of the post-harvest sprays compared with the same materials applied before harvest suggests that the greater the infection the less effective the spray : thus, the more heavily infected Baldwin was less affected by the post-harvest sprays than Mendip Cross. The better the reduction in leaf spot achieved before harvest the less necessary is the post-harvest spraying, and it has been shown in this trial that two pre-harvest zineb sprays were only slightly less effective than 2 pre- and 2 post-harvest sprays. Early spraying is also important because fruit to be sold for processing must generally have been unsprayed for a given period before harvest. If this period were a month, during which the weather was favourable for the rapid spread of infection, leaf spot could have increased by 60 per cent by the time the fruit was picked. It is obviously essential, therefore, to maintain the best possible protection of the foliage before the harvest period, so that the first post-harvest spray can exert the maximum effect.

When differences in the amount of infection present at particular times were translated into values indicating the delay imposed by spraying on the increase in disease to the 50 per cent level, the pre-harvest sprays caused a mean delay of 2–3 weeks on Mendip Cross and 3–4 weeks on Baldwin during the years 1959–61 : the post-harvest sprays imposed a delay (2 weeks) only on the Baldwin bushes. Bearing in mind that only in 1961, on unsprayed Baldwin bushes, did leaf spot infection reach 50 per cent before harvest, delays of more than two weeks in reaching this level would normally mean that at harvest there would be a considerable amount of uninfected leaf worth protecting by the use of post-harvest sprays (4, 5). The addition of two post-harvest zineb sprays resulted, in 1960–61, in a mean increase of 2·6 cwt. per acre on Mendip Cross and 8·2 cwt. on Baldwin, over that obtained with pre-harvest sprays alone.

It has already been suggested that only on leaves on which the fungus has

reached a particular stage in its development at a certain time of the year will the fungus overwinter successfully, and that a post-harvest spray to eliminate this stage might be advantageous (2). In this trial the discharge of ascospores, which are responsible for the primary infection each spring, was found to be most markedly affected by those treatments which reduced infection to the greatest extent. Although the differences in infection during the subsequent summer were not great and, due to cross-infection, short-lived, the results suggest that this aspect of the effect of post-harvest sprays should not be ignored.

In considering the results of a trial of this nature it must be pointed out that because of the arrangement of the plots, and their separation by rows of unsprayed bushes, and because sprays were purposely applied, regardless of the season, at widely separated dates, the materials were not used to best advantage. The importance of early spraying to achieve maximum effect has been stressed. In 1961 leaf spot was present on the experimental bushes three weeks before the first spray was applied : in spite of this the pre-harvest sprays had a considerable effect on the disease. In 1959, however, when the first spray preceded leaf spot by a month, infection never reached 65 per cent during the season.

It seems, therefore, that the adoption of a spray programme consisting of four widely separated zineb sprays, such as was used in this trial, could reasonably be expected to result in considerably increased crops if applied to an entire plantation. Further work will be directed to timing the pre-harvest sprays so as to protect the leaves against the primary infections by ascospores.

Summary.

A 3-year trial comparing the effectiveness of captan and zineb in reducing black currant leaf spot on a mixed plantation of Baldwin and Mendip Cross bushes showed that although two pre-harvest and two post-harvest sprays with zineb were the best treatment, two pre-harvest sprays with zineb were almost as good. While the post-harvest sprays alone were of limited value in reducing leaf spot infection or increasing the crop, they were effective in reducing primary infections in the following year, and proved a worthwhile addition to the pre-harvest treatment. Captan was generally less effective than zineb which, applied on 4 occasions, gave a mean increase in the Baldwin crop of almost 31 cwt. per acre in 1960–61.

Acknowledgments

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STUDIES ON STRAWBERRY MILDEW.*

By O. S. PERIES.†

Introduction.

Powdery mildew of strawberries, caused by the fungus *Sphaerotheca macularis* (Wallr. ex Fries) Jaczewski, was first recorded by Berkeley (2) in 1854. Since then the disease has been observed in all parts of the world where strawberries are grown. Numerous experiments on control by fungicidal sprays have been recorded, but few investigations have been carried out on the biology of the causal fungus and on the host-parasite relationships.

Experimental.

Materials

Potted strawberry plants grown in a greenhouse formed the main source of inoculum for germination and cross-inoculation studies. Plants of 19 varieties of cultivated strawberries and 25 species of other plants, known to be hosts of a morphologically identical fungus, were also maintained in the greenhouse for cross-inoculation trials.

Isolates of the fungus were obtained from different parts of the U.K. for studies on physiologic specialization of the fungus. These isolates were maintained on strawberry plants grown in specially made isolation cabinets covered with nylon netting and muslin.

Methods

Inoculation techniques. Whole plants grown in the greenhouse were inoculated in batches for disease assessment by shaking heavily mildewed plants over them and then maintaining a high humidity in the greenhouse cubicle by watering the pebble benches and floors. Single leaves were inoculated by dusting with conidia from a heavily infected plant by means of a camel-hair brush. The inoculated leaves were enclosed in polythene bags for 48 hours to maintain a high humidity.

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Slide and leaf germination methods. To obtain uniform spore deposits on microscope slides and detached leaves, a cardboard cylinder 2 ft. tall and 6″ in diameter was used as a settling column. Conidia were brushed off mildewed plants at the top end of the cylinder and allowed to settle on material placed at the bottom.

Estimation of percentage germination of conidia on leaf surfaces. An adaptation of the method described by Butler and Mann (5) was used. A piece of " Sellotape ", 1″ wide and 2″ long, was bent back on itself at either end and attached to a microscope slide so that the sticky surface faced upwards. The test leaf was then pressed on the " Sellotape " and later peeled off. The leaf impression was stained with cotton-blue to facilitate conidial counts under the microscope.

Control of humidity. Humidity was controlled by the use of saturated salt solutions (1). Detached leaves, dusted with conidia, were stood in stoppered vials containing water, and these vials were placed in screw-topped museum jars containing saturated salt solutions.

Dispersal of conidia. Two methods of spore collecting were used.

(a) For sampling the spore content of the air from ground level up to 6 ft. the apparatus used was designed by Dr. A. T. K. Corke of Long Ashton. It consists of a wind vane which operates a light metal slide-holder on its opposite arm so that the vaselined slides it carries always face the direction of the prevailing wind.

(b) To collect spores falling on the ground, vaselined slides were placed horizontally on $\frac{3}{4}$″ thick wooden blocks at ground level.

Results.

Host range

Salmon (13, 14) recorded 93 species of flowering plants, belonging to 27 genera and 12 families, as hosts of a fungus morphologically identical with the strawberry mildew fungus. The host range of the mildew on strawberry, however, has not hitherto been clearly established by cross-inoculation. The studies of Salmon (15, 16), Bouwens (4) and Blumer (3) indicate that strawberry mildew is a *forma specialis* of *S. macularis*, specialized to infect strawberries only.

The leaves of 25 different species of plants were inoculated with conidia of the mildew on strawberry to define the host range of this fungus. The results, expressed as a fraction of the total number of leaves inoculated, were as follows :—

Agrimonia eupatoria 0/31, *Alchemilla vulgaris* 0/33, *Epilobium parviflorum* 0/27, *E. montanum* 0/40, *Filipendula vulgaris* 0/30, *Geranium lucidum* 0/17, *G. molle* 0/15, *G. robertianum* 0/21, *Geum urbanum* 0/25, *Humulus lupulus* 0/95, *Potentilla anserina* 0/22, *P. fragariastrum* 45/77, *P. fragiformis* 0/9, P. *reptans* 0/32, *P. tabernaemontani* 0/37, *Poterium sanguisorba* 0/63, *Prunella vulgaris* 0/25, *Rubus idaeus* 0/27, *Rubus* spp. 0/48, *Scabiosa columbaria* 0/57, *Fragaria vesca* 0/36, *cultivated strawberry* 60/60, *Plantago lanceolata** 0/21, *P. major** 0/20, *Taraxacum officinale** 0/28.

Cross-inoculation of strawberry leaves with conidia of the mildew from other hosts gave the following results :—

*Hosts of *S. humuli* var. *fuliginea*.

E. parviflorum 0/25, *H. lupulus* 0/25, *R. idaeus* 0/25, *Rubus* spp. 0/25, *P. lanceolata** 0/25, *P. major** 0/25, *T. officinale** 0/25.

These results indicate that strawberry mildew is a specialized form of the fungus, unable to grow on any plant except the strawberry. *P. fragariastrum* was infected only in the greenhouse and there is no evidence that it can act in the field as an alternative host for strawberry mildew.

Biology of Conidial Germination.

Age of conidia. Conidia from field infections gave a higher percentage germination than those from greenhouse plants because of the greater proportion of senile conidia in the latter. To establish the effect of age on conidial viability, mildewed leaves on greenhouse strawberry plants were shaken vigorously to dislodge senile spores and the plants were then protected from air currents. The percentages of conidia germinating after various periods are presented in Table I.

TABLE I.

EFFECT OF AGE OF CONIDIA ON VIABILITY.

Age (hr.)	24	36	48	60	72	96
Mean % germination	85	81	73	64	58	46

In all subsequent spore germination experiments, young conidia, collected within 24 hours of the removal of senile conidia from infected leaves, were used.

Effect of substrate on germination. Table II shows the effect of various substrates on conidial germination : good germination was obtained only on the surfaces of healthy leaves, irrespective of whether these were leaves of strawberry varieties or of non-host plants.

TABLE II.

GERMINATION PERCENTAGE OF CONIDIA ON DIFFERENT MEDIA.

Substrate	Percentage germination	
	Range	Average
Dry glass slide	5–50	28
Floating on water	5–15	8
Submerged in water	3–5	4
5% sucrose solution	5–17	10
2% water agar	15–20	18
10–15% gelatine	15–20	18
Extract of strawberry leaf	10–17	12
Surface of non-host leaf	60–85	78
Surface of strawberry leaf	65–93	82

Temperature

Effect on germination. The effect of temperature on the germination of conidia on leaf surfaces in a saturated atmosphere is shown below. Each figure is an average for 1,000 conidia after 24 hours incubation.

Temp. °C	0	2	5	10	15	18	20	22·5	25	30	35
% Germination	0	<1	8	12	32	86	88	85	45	30	3

The optimum temperature for conidial germination is 20°C.

Effect on rate of germination. Spore germination on leaves that had been dusted with conidia and maintained at different temperatures in petri dish moist chambers for various periods of time was investigated by the Sellotape impression method. The results, summarized in Fig. 1, show that for rate of germination also the optimum temperature is 20°C.

Storage of conidia at low temperatures. Experiments on the longevity of spores at low temperatures showed that conidia dusted on leaf surfaces can retain their viability for up to 35 days at 0°C. The mycelium of the fungus can remain viable for more than 3 weeks on detached leaves maintained in moist

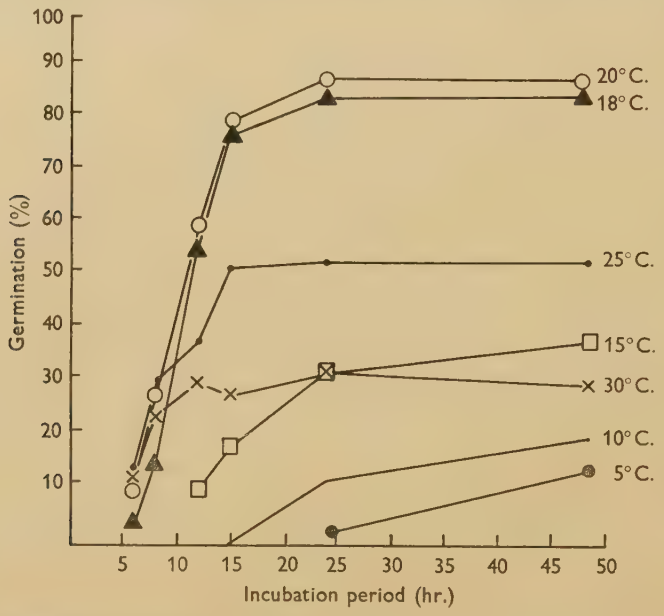

Fig. 1. Effect of incubation temperature on germination of strawberry mildew conidia.

chambers at 0°C and sporulate when the leaves are incubated at 20°C for a few days. Strawberry mildew conidia cannot be stored at temperatures above 0°C, because they either germinate or are killed by higher temperatures. If such conidia germinate in the field during mild periods in the winter, they do not produce infections on cold-hardened overwintering leaves ; consequently these conidia play no part in the perennation of the fungus.

Influence of temperature on infection, growth and sporulation. Although the minimum temperature for spore germination is 2°C, infection does not take place below 5°C. Between 5° and 13°C, the growth of the fungus was slow and

no sporulation took place after 3 weeks. At 15°C growth of the fungus was slow but development normal, sporulation occurring in 5 days. There were no obvious differences in the growth and development of the fungus at temperatures between 18° and 30°C. Strawberry leaves cannot be maintained under high humidity for long periods at temperatures above 30°C.

Relative Humidity

Effect on spore germination. The effects of variation in temperature and humidity on spore germination on strawberry leaves are given in Table III. This shows that strawberry mildew conidia can germinate over a wide range of temperature and relative humidity, the optimum conditions being a R.H. of 97% to 100% at a temperature of 20°C.

TABLE III.

PERCENTAGE GERMINATION OF CONIDIA AT DIFFERENT TEMPERATURES AND RELATIVE HUMIDITIES.

Relative humidity	Temperatures (C.) 5°	10°	15°	20°	25°	30°	35°
Saturated	12	15	32	84	45	33	3
97%	10	15	30	87	40	20	<1
76%	10	12	22	43	17	10	0
34%	8	10	17	20	8	<1	0
12%	2	4	8	17	0	0	0

Effect on infection, growth and sporulation. Humidity had no effect on the processes of infection, growth and sporulation of the fungus; there were no differences in the rate of development at humidities between 12 and 100% at any given temperature.

Light

Light has no apparent effect on the germination of conidia or on the development of the fungus.

Free Water

A suspension of conidia in water was sprayed on to leaf surfaces at different times after the preparation of the suspension. The sprayed leaf surfaces were then dried quickly under a fan, and the percentage germination of conidia estimated in the usual manner after incubation for 24 hours under optimum conditions. The results of this experiment are shown graphically in Fig. 2, which demonstrates that 8 hours immersion reduces germination to less than 10%.

Longer periods of immersion cause the death of the conidia. The vacuolated nature of the cytoplasm changes, the spore contents become granular and some spores burst on prolonged exposure to water. These results are in agreement with those of Corner (6) and Delp (7) with reference to other mildews.

During the course of these investigations no germination was ever recorded on leaf surfaces carrying free water.

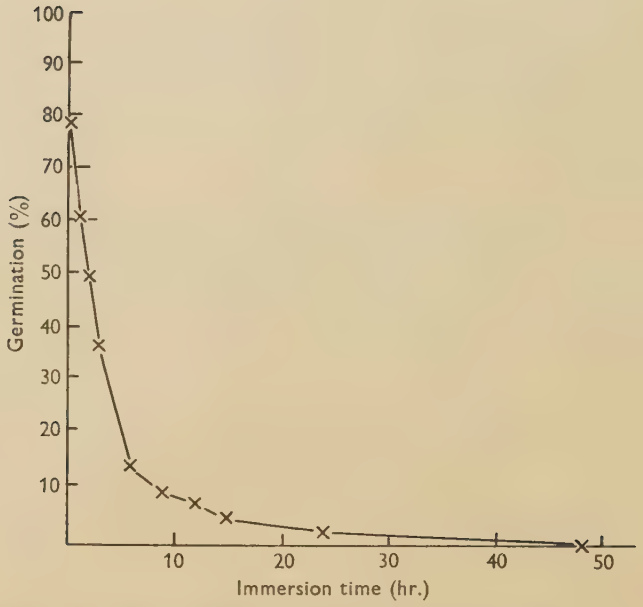

Fig. 2. Percentage germination of strawberry mildew conidia after different periods of immersion in water.

Dispersal of conidia

The greatest numbers were trapped during the afternoons, between 12·00 and 16·00 hours, extremely few spores being trapped during the night (20·00 to 08·00 hours). This type of diurnal periodicity in spore liberation has also been observed in other powdery mildews (17, 19). The number of spores trapped is greatly reduced by rain. Spore numbers increase when dry weather follows rainy spells, but recovery generally takes about three days as shown in Fig. 3.

Records from vaselined slides placed at 0–60 ft. from a heavily infected strawberry plant showed that almost all the spores were deposited within 10 ft. of the infection source. Studies of the vertical distribution of spores showed that the number of conidia trapped decreases sharply with increasing height, 91% of the spores being trapped within 6 in. of ground level.

Production and function of perithecia

Strawberry mildew rarely produces perithecia (3, 13) : they were first recorded in the U.K. in 1960 by Khan (10) on greenhouse material : in this country they have not been recorded in the field.

Experiments made in controlled environments, during the present studies, have indicated that the production of perithecia is favoured by severe infection of the plant under conditions of low light, high humidity (50–90%) and a temperature ranging between 60 and 80°F. Leaves bearing perithecia were overwintered outdoors, in the greenhouse, on the laboratory bench and in a refrigerator at 0°C. Random samples were removed from these specimens at

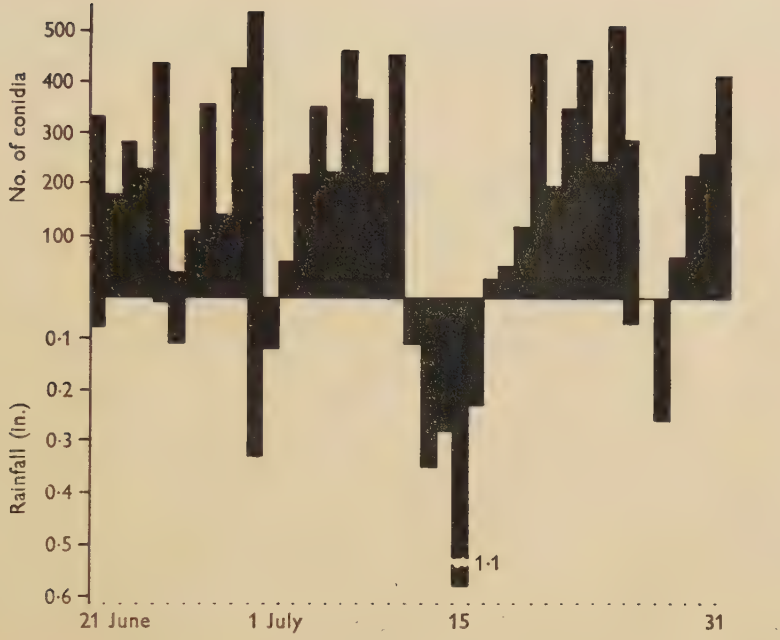

Fig. 3. Effect of rain on dispersal of conidia of strawberry mildew (1961). Note lag between end of rainy spells and return of spore-catches to pre-rain levels.

regular intervals, placed on moist filter paper discs and then held in close contact with green leaves. No infections were recorded in any of these experiments.

Samples from the material overwintering under different conditions were examined microscopically in early spring. It was found that the perithecia overwintered outdoors contained either no asci or deformed asci in which the ascospores had disintegrated. It was concluded from these observations that the perithecia of strawberry mildew are produced in the U.K. only under unusual environmental conditions, and that when produced they play no part in the perennation of the fungus.

Overwintering

Evidence that the strawberry mildew fungus perennates in the mycelial stage on overwintering green leaves was obtained in 1960 (11) and confirmed by further studies carried out during the winter of 1960-1961. As no other host has been demonstrated, and no other method of perennation, this stage appears to be vital to the continuance of the fungus.

Host/Parasite Relationships.

Of the strawberry varieties commonly grown in the U.K., Royal Sovereign and Cambridge Vigour have been found most susceptible to mildew. No variety

immune to the disease is known, but Huxley and Cambridge Favourite are relatively resistant. Some less popular varieties like Cambridge 456 (12) and Merton Princess (18) have also been found to show some degree of resistance.

Varietal susceptibility

The following classification, based on that of Grainger (8) was used :

1. Highly resistant : no macroscopically visible infection.
2. Very resistant : slight infection, 0·5–5% of leaf area covered by fungus.
3. Moderately resistant : 5–10% of leaf surface infected.
4. Moderately susceptible : 10–20% of leaf surface infected.
5. Very susceptible : generalized infection covering 20–40% of leaf surface.
6. Highly susceptible : widespread infection covering more than 40% of leaf surface.

The results of a survey are summarized below :—

Infection type	Varieties
Very resistant	Camb. Favourite, Huxley, Late Pine.
Moderately resistant	J.I. 1098, Merton Princess, J.I. 580, Talisman, Camb. 449, Clopton, J.I. 929, J.I. 917.
Moderately susceptible	Axbridge Early, Camb. Early, Red Rich, Premier, Connie Louise, Rival, Prizewinner, Stoke Edith, Camb. 141, Redgauntlet, Rearguard, Jucunda, J.I. 773, Scarlet Queen.
Very susceptible	Surprise, Hampshire Maid, Regent, Triomphe, Regina.
Highly susceptible	Royal Sovereign, Coronation, Camb. Vigour, Madam Lefebvre, Deutsche Evern, Sir Joseph Paxton.

All the varieties which proved resistant to the disease had a thick leathery type of foliage with glossy dark-green upper surfaces.

It was found that leaf age and plant environment have an important effect on symptom expression. Young leaves were more susceptible than mature leaves, and plants grown in the greenhouse were more susceptible than those grown outdoors. This difference was most striking in the more resistant varieties, which appear to lose their resistance when grown under glass.

Physiologic Races

Investigations were carried out with isolates of the fungus obtained from different parts of the U.K. to find whether there was any physiologic specialization of the fungus. Detached leaves of six varieties of strawberries, with known

differences in reaction to mildew, were dusted with conidia from each isolate of the fungus and incubated under optimum conditions of temperature and humidity.

All the isolates induced symptoms of similar pattern and virulence on any given host variety ; their conidia, too, were of similar size. It was therefore concluded that there are no physiologic races of the fungus on strawberry in the parts of the country from which isolates were obtained.

Effect of Climate

Laboratory tests have shown that free water kills the conidia, the conidiophores and the fungal mycelium in that order. Well-developed mycelium can survive under surface films of water for three to four days and restricted areas of the mycelium can survive for over a week.

Field observations showed that few new infections took place during periods of prolonged rainfall. In 1960, the latter half of June was dry at Long Ashton, and strawberry mildew spread rapidly, but rainy weather between early July and mid-August restricted the spread and mildew was not noticeable again until the dry month of September. In 1961 the disease showed the same characteristics and spread quickly during the dry months of June and July (Fig. 3).

Discussion.

The minimum, optimum and maximum temperatures for germination of strawberry mildew conidia are respectively 2°, 20° and 35°C, but infection occurs only between 5° and 30°C and sporulation only between 15° and 30°C. Relative humidity has some effect on germination of conidia but none on growth and sporulation of the fungus. Free water is injurious to conidia, which are killed by relatively short periods of exposure to water. These are the factors which account for the profuse development of the fungus during periods of hot dry weather inimical to other obligate plant pathogenic fungi, and check its spread during rainy weather.

It has been demonstrated that the spores of this fungus are not likely to travel long distances, but that it is likely to spread step-wise over short distances. These studies have also shown that the causal fungus perennates only on overwintering green leaves of strawberry. These two factors indicate the value of winter defoliation as a method of controlling the disease. If the disease is eradicated from a certain area it is likely to spread relatively slowly back into that area through spores carried in from distant sources. Therefore, the indirect control of the disease by destroying overwintering foliage merits exploration, especially in view of the observations of Guttridge *et al.* (9) that post-harvest defoliation of strawberry plantations increases the following season's crop by removing a flower-inhibitor produced in the leaves. Winter defoliation may thus serve a dual purpose.

Preliminary trials with diquat, used at the equivalent of 1 lb./100 gall./acre in late November, proved promising for the destruction of foliage, but the effect on buds requires further investigation.

Summary.

1. The host range of the powdery mildew occurring on strawberry indicates that it is a specialized form of *Sphaerotheca macularis*, unable to parasitize plants other than strawberry.

2. Details of the biology of spore germination are given.

3. The factors affecting the dispersal of the conidia of the fungus are described.

4. A list is given of the susceptibilities of 35 varieties of strawberries to infection.

5. The method of perennation of the fungus is established, and winter defoliation is suggested as a means of controlling the disease.

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PHYTOTOXICITY TRIALS OF SOME SPRAY OILS ON BANANA LEAVES.

By A. T. K. CORKE and V. W. L. JORDAN.

Oils have previously been used as insecticides, herbicides, fungicide and insecticide carriers, to coat apples to reduce losses in store (4), to carry fungus spores in experimental inoculations (7) and to prolong the life of fungi in culture (2). They have only rarely been used as fungicides : in the soil to reduce infection by root-rotting fungi (3) or against mildew species (1), but never to the extent now found practicable in the control of banana leaf spot.

Since 1955, when Guyot and Cuillé (6) showed that the destruction of banana leaves by the leaf spot fungus, *Mycosphaerella musicola* Leach (*Cercospora musae* Zimm.), could be retarded by spraying the leaves with oils, their use for this purpose has become widespread in the banana-growing areas of the world. The effective control of this disease by the application of as little as one gallon of oil per acre, as a very fine mist, gives this method obvious advantages over the conventional large-volume application of aqueous fungicides, and makes it particularly suitable for plants in difficult terrain, either for spraying from the ground or from the air.

Because of the threat of phytotoxic damage, the last few years have seen a great deal of work on the choice of oils for use on bananas, and on rates of application which will provide adequate protection while reducing the risk of phytotoxic injury to the lowest possible level. Of particular interest has been the study of how control of this disease by a non-fungicidal material has been achieved. An investigation into this aspect of the problem was begun at Long Ashton in 1958.

While the banana plants needed for this work were being assembled, a preliminary examination of the activity of some oils on a number of pathogenic fungi commonly occurring in Britain was carried out (5). It was found that not only did the effect of the oil used vary with the species and the stage in the life-history of the fungus (conidium, ascospore or mycelium), but that banana leaves were less liable than the leaves of temperate fruit plants to injury by the oils tested. Further experiments concerning the effect on banana leaves of these and other oils are described briefly below ; a full account will later be published elsewhere.

Experimental.

Samples of a number of oils, some currently used for the control of leaf spot, were obtained from commercial sources.

Materials.

P31, white oil ; JD2, spindle oil ; DO, Diesel oil ; DPI, Diesel oil plus phytotoxicity inhibitor from the French Cameroons. *Spray oils* E (Ecuador) ; SE (British Cameroons) ; CO (French Cameroons) ; GO (French Guinea) ; ICO (French Ivory Coast) ; MSBO ; BLSO ; RO ; PO.

The bananas used were of two varieties, Dwarf Cavendish and Jamaican Lacatan.

Methods.

The oil to be tested was applied with a small swab of cotton wool to one or both surfaces of one of the two youngest open leaves, so as to give as light but as complete a cover of the chosen area of the leaf as possible. In most cases the treated areas of the leaves could be distinguished after two days by their translucent appearance : this, and the damage which subsequently appeared, was assessed as the percentage leaf area affected after 2, 4, 7, 14 or 28 days. Some plants treated with selected oils were kept at mean temperatures of about 70°F and were either exposed to diffuse natural daylight or to a total of 12 hours illumination per day, the daylight being supplemented by mercury vapour lamps controlled electronically to switch on when the sun was obscured. These environmental conditions are summarized in Table I.

TABLE I.

ENVIRONMENTAL CONDITIONS IN GLASSHOUSE DURING PHYTOTOXICITY TRIALS.

Experiment number	Date	Banana variety	Treatment	Temp. °F	Light	Humidity
1	Oct. 1958	Dwarf Cavendish	Selected oils (see Table II)	57–60	Normal daylight	Moderate
1a	Jan. 1959	,,	,, ,, (see Table III)	67–77	(i) 12 hrs. illumination (ii) Normal daylight	High
2	Sept. 1960	Lacatan	,, ,, (see Table IV)	52–87	Normal daylight	Moderate
2a	Oct. 1960	,,	,, ,, (see Table V)	67–75	(i) 12 hrs. illumination (ii) Normal daylight	High
3	Dec. 1960	,,	Copper oxy-chloride in oils (see Table VI)	69–78	Normal daylight	Moderate

To assist in the study of the movement of oil within the leaf, a number of oil-soluble fluorochromes were added to the oils used ; the treated leaves were later examined at intervals under ultra-violet light. Portions of leaf were also sectioned on a freezing-microtome for microscopic examination.

The effect of some of the oils on the growth of the fungus in culture was studied by seeding agar plates with spores and flooding the surface with oil.

Results.

Experiment 1.

This experiment compared the effects of applying eleven selected oils to upper or lower leaf surfaces of the variety Cavendish. Assessments of the area of leaf affected by the oil treatments, given in Table II, suggest that penetration was generally more rapid and damage more severe when the oil was applied to the lower surface of a leaf. While some leaves showed the maximum level of translucence within the first two days, others did not : extensive translucence was not necessarily followed by a high level of injury as measured by the intensity of oil-flecking (Plate XII, Fig. II). This was

TABLE II.

PERCENTAGE LEAF AREA AFFECTED BY OIL TREATMENT : VAR. CAVENDISH.

Time after treatment	Oil translucence				Phytotoxic injury			
	2 days		4 days		7 days		14 days	
Surface treated	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Oils								
P31	60	100	90	100	35	35	100	100
JD2	40	90	50	95	55	50	80	100
DO	70	100	70	100	55	75	90	100
DPI	0	40	0	60	0	5	0	10
MSBO	30	50	70	90	10	15	30	20
E	0	30	20	50	5	10	10	10
SE	0	10	0	10	0	0	0	0
CO	0	40	10	40	10	10	10	10
GO	10	40	20	60	5	0	30	0
ICO	0	40	10	80	0	20	0	60
BLSO	40	80	40	80	10	5	30	30

characteristic of all the oils except P31, JD2 and DO but was particularly marked with MSBO and BLSO.

Experiment 1*a*.

Four oils of low phytotoxicity were later used to examine the effect of light and shade on the development of damage on the same variety. Table III shows that injury due to treatment of the lower surface was generally

TABLE III.

EFFECT OF LIGHT AND SHADE ON PHYTOTOXICITY : VAR. CAVENDISH.

Percentage leaf area affected.

Time after treatment	Light				Shade			
	7 days		14 days		7 days		14 days	
Surface treated	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Oils								
DPI	0	20	10	50	5	10	20	15
E	0	5	0	5	0	0	0	20
SE	0	0	0	0	0	0	0	0
CO	5	50	5	50	1	10	20	60

greater than that following treatment of the upper surface, but while DPI caused more damage on the lower surface under normal light, it caused slightly more damage on the upper surface of the shaded plant.

Experiment 2.

This was a parallel experiment with the variety Lacatan. Although the degree of translucence was not estimated in this case, its presence was recorded (Table IV). Lacatan leaves at first showed less translucence than Cavendish,

TABLE IV.

PERCENTAGE LEAF AREA AFFECTED BY OIL TREATMENT : VAR. LACATAN.

Time after treatment	7 days		14 days		21 days	
Surface treated	Upper	Lower	Upper	Lower	Upper	Lower
Oils						
P31	20	50	30	80	50	90
JD2	20	70	40	80	60	100
DPI	0	10*	20*	30*	60*	80*
MSBO	30	50	40	80	60	100
E	10	10	30*	20	60*	30
SE	10	10	10	10	20	20
CO	40	60	50	80	80	100
GO	10*	0	10*	10*	10*	10*
ICO	10*	10*	20*	20*	20*	40*
BLSO	0	10*	10	10*	10	10*
RO	0	0	0	0	0	0
PO	0	0	0	0	0	0

* Oil translucence visible.

and while injury appeared sooner, it developed more slowly.

Experiment 2*a*.

Selected oils were again applied to leaves exposed to long hours of light or shade. The results, given in Table V, again show greater injury when oil

TABLE V.

EFFECT OF LIGHT AND SHADE ON PHYTOTOXICITY : VAR. LACATAN.

Percentage leaf area affected.

	Light						Shade					
Time after treatment	7 days		14 days		21 days		7 days		14 days		21 days	
Surface treated	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Oils												
SE	0	0	0	0	0	10	0	10	0	10	10	10
GO	0	10*	10	20*	20	40*	10	10	20	30	20	40
ICO	10*	10*	30*	30*	40*	70*	0	0	20	20	30	40
BLSO	0	10*	0	10*	0	10*	10	20	10	30	20	50
RO	0	0	0	0	0	0	0	0	0	0	0	0
PO	0	0	0	0	0	0	0	0	0	0	0	5

* Oil translucence visible.

was applied to the lower leaf surface, but with Lacatan the effect of environmental conditions on phytotoxicity was more marked : GO and BLSO caused more damage in the shade while ICO caused more in the light.

In these two sets of experiments, P31 and JD2 showed a consistently high level of phytotoxicity on leaves of both varieties, while most of the other oils appeared to cause little visible damage, in spite of imparting extensive translucence to the oil-treated area. In most cases the injury on Lacatan was greater than on Cavendish, but oil E caused less damage on Lacatan. The least phytotoxic oils under all conditions on both varieties were E and SE, but on Lacatan RO and PO were superior to both these oils.

Experiment 3.

A third group of Lacatan plants was treated with suspensions of copper oxychloride (concentrate diluted to give 0.19 lb. metallic copper per gallon) in ten of the oils used in the previous experiments. Table VI shows that there

TABLE VI.

PERCENTAGE LEAF AREA AFFECTED BY OIL-COPPER TREATMENT : VAR. LACATAN.

Time after treatment	7 days		14 days		21 days	
Surface treated	Upper	Lower	Upper	Lower	Upper	Lower
Oils						
DO	20	60	20	60	20	60
DPI	0	0*	0	0*	10	10*
MSBO	5	0*	5	0*	10	0*
E	5*	5*	5*	5*	5*	5*
SE	10*	0*	10*	0*	10*	0*
CO	10	40	10	40	20	60
GO	0*	0*	0*	0*	20*	20*
ICO	5	5*	10	5*	15	10*
BLSO	10*	0*	20*	0*	40*	20*
RO	0	0*	0	0*	10	10*

* Oil translucence visible.

was generally very much less phytotoxic injury than with the same oils alone (Experiment 2), and except with DO and CO, the injury was more pronounced on leaves treated on the upper surface than on those treated on the lower surface. The oil translucence was slightly more marked than with the oils alone, except with DPI and ICO.

While these results suggest that the presence of copper in the oils was beneficial in reducing the intensity of injury, it should be noted that the tests with the oils alone were made at a higher mean temperature and light intensity than those with copper (Table I).

Examination under ultra-violet light, both incident and transmitted, showed that although DPI emitted a green fluorescence when subjected to ultra-violet light, the other oils could be more readily detected by the addition of oil-soluble fluorochromes. By a detailed comparison of the fluorescence emitted by the cells of a healthy leaf with that of damaged or moribund tissues, and by the use of a dye which identifies the oil with certainty, the

distribution of relatively minute amounts of oil, and the changes induced by its presence amongst the cells, can be seen under the microscope. The technique involves the interpretation of subtle changes in colour which cannot be reproduced by normal photographic processes.

The photomicrograph in Plate XI (Fig. I), shows a section of leaf, 10 weeks after treatment of the lower surface with oil SE plus Red R dye, cut transversely through a fleck of oil-damaged tissue. Under U.V. light the red oil globule (a) lies in an area fluorescing strongly with red, superimposed on the white colour typical of injured cells : this colour predominates in the main area of damage, and in the palisade layer (d) imparts an orange-yellow tinge to the cells, which normally emit a deep brick-red colour. The vascular and epidermal layers also show changes, the vessels being bright yellow and the epidermis almost colourless, but with the stoma pores clearly defined by a bright yellow fluorescence. On the fringes of the area of visible injury, the fluorescence in the palisade and mesophyll cells indicates changes which would not have been seen with the naked eye.

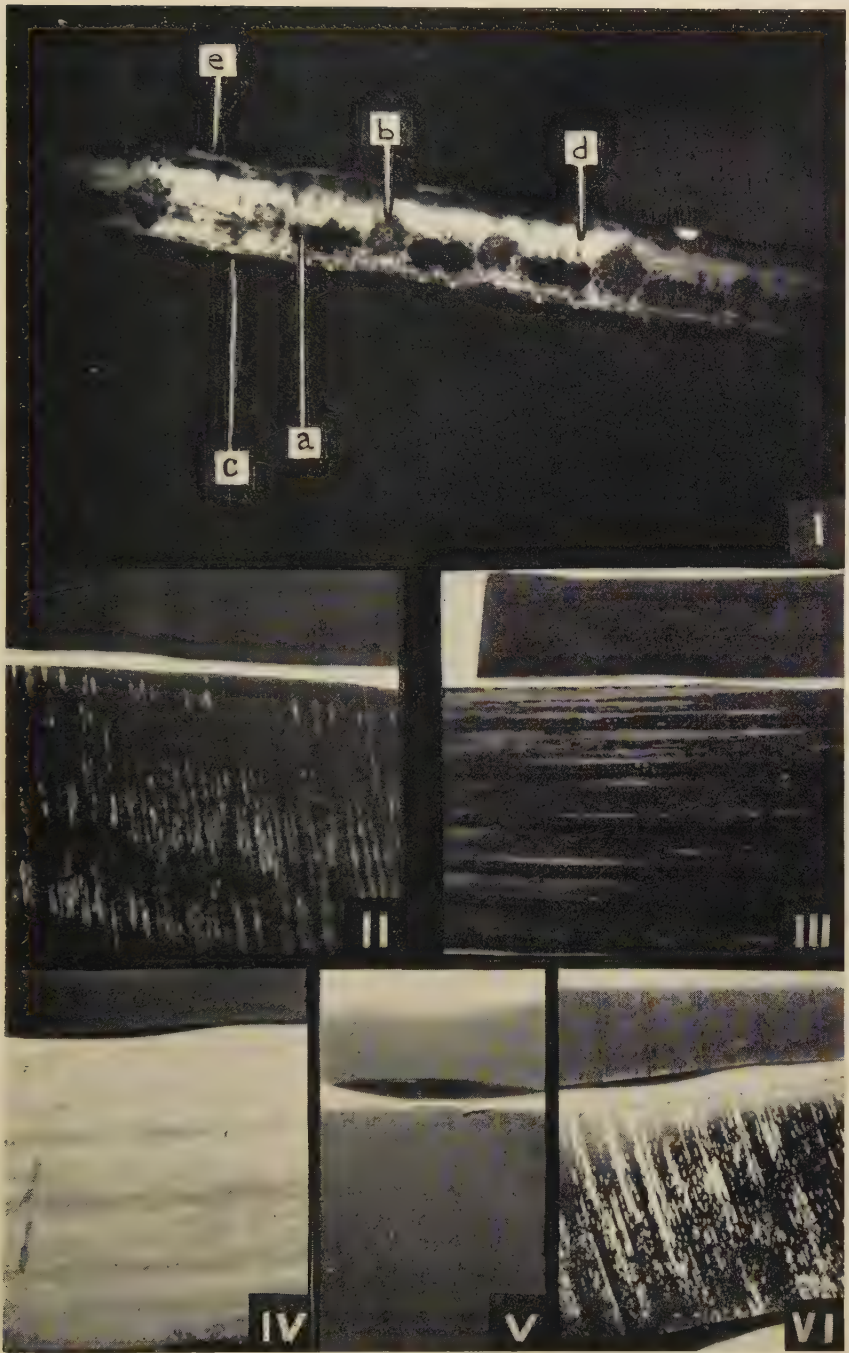
The results so far obtained suggest that the speed and extent of penetration of a leaf from the surface differs with the oil used and the surface to which it is applied. The rapid penetration of the oils DO and DPI through a leaf, within one hour of treatment, can be seen in Figs. II and III respectively (Plate XI). Although the oil-flecks on the leaf treated with DO appearr ather heavier than on the leaf treated with DPI, the only visible sign of the presence of oil at this time was as dark green streaks, both leaves being very similar. Fig. VI shows the increased penetration which took place after two more weeks in the leaf treated with DPI. Under daylight, the leaf showed no injury at this time, but the oil-flecks were discernible as dark green streaks. Fig. IV shows the cover obtained by spraying a leaf with oil at a rate of 0.04 ml. per 100 sq. cm. Fig. V. shows the rate of penetration of oil from upper to lower surface compared with that from lower to upper surface (Fig. III).

Effect of oil on Cercospora musae *in culture.*

In culture, the banana leaf spot fungus growing on agar flooded with selected oils showed slightly more growth under ICO than in the control cultures flooded with water : growth under GO was similar to that in the control cultures, and much less under CO and RO. Spore germination under all these oils was similar to that of the controls. Fig. I, Plate XII, shows the plate cultures after 14 days, when the growth on the control plates was less vigorous than on the others. Spores from the oil-treated cultures placed on banana leaves germinated in the normal way.

Discussion.

In these preliminary experiments on the effect of oils on the leaves of banana plants grown under glass in this country, variations in light intensity, and to some extent temperature, may have had an effect on the injury caused by the treatments. Care was taken, however, to carry out similar trials in the autumn and winter, when more control over temperature could be exercised, and additional light could be supplied, to make successive trials more comparable. The results show that although they had little or no fungistatic effect on the fungus concerned, a number of the oils used to control this disease



Photographs taken under ultra-violet light showing the presence of oil by fluorescence. *Fig. I.* Photomicrograph of section of banana leaf 10 weeks after treatment of lower surface with oil SE plus Red R dye. (a) Oil globule : (b) Vascular tissue : (c) Stoma pores : (d) Palisade cells : (e) Upper epidermis. *Figs. II–VI.* Surface views of treated and untreated areas of the same leaf : untreated leaf above. (II) Upper surface 1 hour after treatment of lower surface with DO plus Red R. (III) Upper surface 1 hour after treatment of lower surface with DPI plus Red R. (IV) Lower surface 1 hour after spraying with DPI plus Red R. (V) Lower surface 1 hour after spraying upper surface with DPI. (VI) Upper surface 2 weeks after treatment of lower surface with DPI plus Red R.

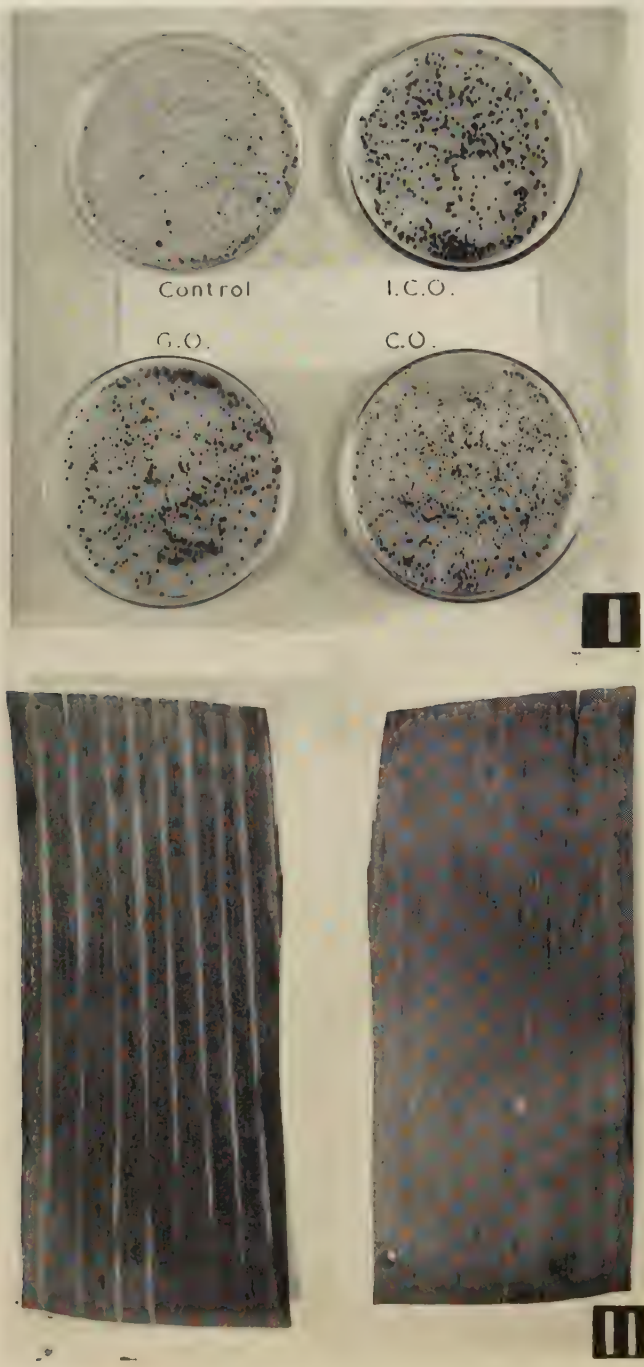


Fig. I. Plate cultures of *Cercospora musae* 14 days after flooding with oil.
Fig. II. Oil-flecking on leaf of Lacatan treated on the lower surface with SE plus Red R ; after 10 weeks. *Left* : Upper surface. *Right* : Lower surface.

in the plantations caused considerable damage in the present trials, in which they were applied in excess of the amount normally used in practice. Nevertheless, if no injury results from the presence of a particular oil in a leaf, there should be no injury if the amount present is increased to a reasonable extent, but if, at the rate of field application, injury results which can only be detected by microscopic examination, it may go undetected. A few oils tested were found to cause no injury which could be classed as oil-flecking even at the high rates used.

The use of ultra-violet light to trace the movement of oils in the leaf has shown promise as a means of detecting injury due to the presence of oil in the absence of any sign of damage normally visible to the naked eye. The ultimate aim in the control of leaf spot by oil spraying is to select oils which will cause no injury to the plant after a number of applications. Field trials may reveal a large number of oils which cause no apparent injury after many applications ; the selection of those having the smallest effect may then depend on microscopic examination and physiological studies.

Summary.

Leaves of two varieties of banana grown under glass were treated with oils used in various parts of the world in the control of banana leaf spot. Phytotoxic injury was found to be more marked on Lacatan than on Cavendish leaves and more severe when the oil was applied to the lower surface of either variety. Light and shade had little effect under the experimental conditions to which the treated plants were subjected. Fluorescent dyes showed promise for detecting changes in treated tissues in which no external symptom of injury was apparent.

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EXPERIMENTS IN THE TRANSFER OF THE BLACK CURRANT GALL MITE (*PHYTOPTUS RIBIS* NAL.) AND OF REVERSION

By B. D. SMITH.

It has long been known that the black currant gall mite is associated with the disease reversion, and Massee showed in 1951 (1) that reversion can be transmitted by the mite. There are many aspects of the relationship between the mite and reversion on which more information is required but is not readily available because of the difficulty in handling the mite experimentally.

The mites, which are just visible to the naked eye, are soft skinned, very delicate and prone to desiccation. Some features of their behaviour have been described (2, 3) but as yet no method of culturing them outside the environment of black currant buds, where they feed and reproduce, has been found. They can remain alive and active in petri dishes for several days provided that the humidity is high and they are not very strongly illuminated. They readily attach themselves to objects which touch them and use has been made of this behaviour in experimentally transferring mites singly or in groups from infested buds to other sites.

Mite Transference.

Mite transference experiments were begun in 1958 ; the most successful transfers were made using mites from galled buds collected in the field during the normal mite migration period (2). Two types of potted black currant plants were used : seedlings (Baldwin open-pollinated) approximately twelve inches high, and one-year-old Baldwin plants from the Long Ashton nurseries. These plants were kept, both before and after inoculation with mites, in insectaries under climatic conditions approximating to those externally.

Mites were placed, singly or in groups, near or in the axils of new shoots by allowing their attachment to a single hair. Subsequently bud dissections were made to estimate the size of the resulting mite infestations. Mites were also transferred in larger numbers by bisecting galled buds and attaching the halves to new shoots with fine pins. All mites used in these experiments were obtained from buds on bushes whose leaves had shown symptoms of reversion.

After inoculation all plants were grown in isolation for at least one year so that the leaf symptoms of reversion could be observed ; flower symptoms were used only to confirm the incidence of reversion given by leaf symptoms. The plants received no foliar sprays but, except during a two week period after mite transference, regular fumigations were carried out to eliminate any other fauna present.

Control groups of plants not receiving mites were kept under the same conditions as the inoculated ones.

In May, 1958, 1640 mites were transferred singly both to seedlings and to one-year-old plants. Galled buds were occasionally observed later near the site of inoculation but rarely more than two or three buds distant from it. They occurred, however, on only a small number of the plants inoculated, and dissections showed that while mites had successfully penetrated to the centres of many buds, they had survived and reproduced in fewer than 1% of the

inoculations. The first bud dissections were made approximately one month after inoculation ; mite eggs were observed, not only where several mites had penetrated the same bud but where single mites had been successfully transferred.

Where groups of approximately 5 and 20 mites were transferred the resulting infestations were more successful : 8% and 89% respectively.

Bud dissections on the uninoculated control plants failed to show the presence of mites.

Transference of Reversion.

After the mite transference experiments of 1958 and others made subsequently in 1959, leaf symptoms of reversion appeared in 1959 and 1960 on 46% of the plants that had become infested, including some of those on which only a single mite had been placed. Leaf symptoms appeared for the first time on another 5% of these plants in the second year after inoculation.

Whilst most of the uninoculated plants appeared to remain free from reversion throughout the experiment, four of these plants in the second year after the inoculations showed leaf symptoms of reversion which were persistent and therefore not attributable to false reversion. Whilst it is not possible to state that contamination with gall mite did not occur, it would have been very unlikely to do so under the conditions of the experiment. However, despite fumigations, contamination of experimental plants by glasshouse red spider (*Tetranychus urticae* (Koch)) and various aphid species did occasionally occur.

Many cases of reversion, apparently not associated with black currant gall mite, have been reported. Massee tried unsuccessfully in 1951 (1) to transmit reversion under laboratory conditions with the Currant capsid bug, *Lygus pabulinus* (L), and four species of currant aphids. In 1960, attempts were made at Long Ashton to continue these transmission experiments by confining a range of species, similar to that used by Massee and collected from reverted tissue, in cages which were placed on the upper and lower surfaces of leaves on potted plants in outdoor insectaries. These cages were constructed from plastic cylinders, 1″ high and 2″ diameter, with ends of fine nylon mesh ; they were intended to confine the feeding and possible virus transfer to particular sites of the plant. Cage conditions, however, induced greater movement in all insects than that in the field ; feeding time was therefore much reduced, and in no case could a transfer of reversion be detected.

Groups of specimens of the glasshouse red spider were also collected from reverted black currants in the field and confined to uninfected leaf tissue, but again no virus transfer could be detected. Since in none of these experiments were conditions entirely satisfactory, attempts are now being made to obtain more natural behaviour from caged specimens.

Mechanical transmission.

To detect reversion rapidly in black currant tissue an indicator plant was sought amongst those found suitable for virus diseases. The method used in an attempt to transmit reversion mechanically was that described by Cadman (4).

During 1959 a number of experiments were carried out by taking approximately 1 g. reverted leaf tissue, macerating with 2·5 ml. of a solution of 2·5% v/v commercial nicotine in distilled water and rubbing on the surface of healthy leaves with the aid of an abrasive compound after further dilution. The

indicator plants used were : *Lycopersicum esculentum* (var. Moneymaker), *Cucumis sativus* (var. Butcher's Disease Resistant), *Nicotiana rustica* and another unknown species of tobacco, *Petunia hybrida* and *Chenopodium amaranticolor*.

None of the indicator plants showed symptoms different from those of plants treated only with abrasive and water, when used as above or when the macerate was injected into young stems with a hypodermic needle.

In June 1959 macerates were made from large numbers of mites extracted from galled buds on reverted bushes by partial dissection and agitation in water. They were rubbed on the leaves of healthy black currant seedlings and indicator plants and also injected into the stems. No significant symptoms were subsequently shown.

Summary.

Techniques for the transference of the black currant gall mite are described. A single mite was found capable of starting an infestation leading to bud galling and the transmission of reversion. Some delay in the appearance of leaf symptoms of reversion occurred in these experiments.

No indications of the transmission of reversion to healthy black currants were obtained with *Lygus pabulinus* (L), various species of aphids and with *Tetranychus urticae* (Koch), and attempts to transfer reversion to indicator plants mechanically, by rubbing reverted leaf extracts and mite tissue on healthy leaves and by injecting them into stems, also failed.

Acknowledgments.

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A NOTE ON THE JUICE COMPOSITION OF CIDER APPLE VARIETIES.

By L. F. BURROUGHS.

An accompanying paper (1) in this report describes the pomological characteristics of ten cider apple varieties recommended for general planting and briefly records the average composition of their juices. The present paper describes the derivation and significance of the information on the average juice composition.

Figures for the average juice composition of all the varieties described, except Michelin, were previously given in the Annual Report for 1953 (2). Unfortunately, the information then available for some of the varieties was too limited to give accurate estimates of the average composition of their juices. From a statistical study of the variability occurring among 308 samples of Kingston Black juice, it was calculated that about 50 samples were required in order that the 95% confidence limits of the means of S.G., acidity and tannin content should be within $\pm 10\%$ of their true mean values.

That such wide variability could occur within the variety was thought to be due to the fact that the 308 samples came from all parts of the cider-growing area over a period of 30 years, and were therefore subject to extreme variations of cultural and climatic conditions. It was assumed that other varieties of cider apple could be expected to show the same order of variability and that the objective of finding the average juice composition of a given variety would therefore be slow and costly (equivalent to 10 samples a year for 5 years). For some varieties it would be difficult, or even impossible, to obtain 10 different samples in one season. Furthermore, if the juice composition of a variety could vary so widely, there would be little advantage in knowing accurately its average value, since the composition of a single sample would probably differ considerably from the average.

This was the position in 1955 when it was decided that pomological descriptions of the recommended varieties should be accompanied by more reliable figures for juice composition. For several of the varieties the averages given in 1953 were based on too few samples and much more information was needed. It was hoped, however, that by avoiding abnormal fruit samples, e.g. from extreme cultural conditions, it would be possible to arrive at a reliable average juice composition on less than 50 samples ; 20 was thought to be a practicable number for most varieties.

A more optimistic view has, however, resulted from a re-examination of the original Kingston Black juice analyses by a more refined statistical method. It is now found that only 15 samples are needed for the 95% confidence limits of the mean to lie within 10% of the true mean composition. It follows therefore that, even for varieties of which there were relatively few samples, the composition quoted in the Annual Report for 1953 was probably much nearer the true average than was previously believed. This is confirmed by the fact that the average composition based on results accumulated since 1953, for each of these recommended varieties, is very similar to that quoted in 1953. Because of this agreement, there is no reason to distinguish between the samples before and after 1953, and the figures for juice composition of the varieties recorded in Table I are averages of all available samples.

TABLE I.

JUICE COMPOSITION OF CIDER APPLE VARIETIES.

Variety	Number of samples	Specific Gravity	Acidity % (as malic acid)	Tannin % (see ref. 3)
Ashton Brown Jersey ..	17	1·054	0·14	0·23
Bulmer's Norman ..	45	1·053	0·24	0·27
Court Royal	21	1·050	0·21	0·11
Dabinett	117	1·057	0·18	0·29
Kingston Black	339	1·061	0·58	0·19
Michelin	16	1·050	0·25	0·23
Stoke Red	33	1·052	0·64	0·31
Sweet Coppin	37	1·052	0·20	0·14
Tremlett's Bitter	28	1·052	0·27	0·34
Yarlington Mill	114	1·052	0·22	0·32

The statistical examination of the results of juices obtained since 1953 revealed other points of interest.

(1) The combined variance of the specific gravities of all samples examined since 1953 was less than half the variance of the Kingston Black specific gravities. This is attributed to the greater extremes of climate and cultural conditions affecting the Kingston Black samples. If this is expressed in terms of the number of samples (n) required for the 95% confidence limits to lie within $\pm 10\%$ of the true mean, it is calculated that for Kingston Black $n=15$ and for the other varieties $n=8$.

(2) The standard deviations of the titratable acidity results are proportional to the means for the different varieties. Again, $n=15$ is required for 95% confidence limits within $\pm 10\%$ of the mean.

(3) The standard deviations of the tannin contents remain of the same order irrespective of the mean. The means of the varieties range from 0·11 to 0·34%; for an average tannin content of 0·25%, $n=18$ is required for 95% confidence limits within $\pm 10\%$ of the mean, but for tannins as low as 0·10%, $n=18$ would give the mean only to within $\pm 20\%$ (i.e. $\pm 0{\cdot}02\%$ tannin). In practice, however, this would be sufficient, since a variety with such a low tannin content would not be classed as a bittersweet and its tannin content would not be regarded critically.

The number of samples (n) required in order that the average composition shall be within specified limits of the true varietal average (m) are tabulated below.

Range of composition (95% confidence limits)	Number of samples (n)		
	S.G.	Acidity	Tannin
$m \pm 20\%$	4	8	9
$m \pm 10\%$	8	15	18
$m \pm 7{\cdot}5\%$	14	27	32
$m \pm 5\%$	32	60	72

Because the variability of tannin content is not proportional to its mean value, the values of n given above are for an average tannin content of 0·25%. These figures give a guide to the reliability of the averages quoted for the

different varieties (Table I). Thus one may conclude that, with 95% confidence, 20 samples will give the average composition within less than 10% of the true varietal means for S.G. and acidity and within about 0·02% tannin content.

The average juice compositions of the different varieties quoted in the table are regarded as sufficiently accurate for practical purposes and the accumulation of further data is unlikely to alter these averages appreciably.

It is apparent from the table that, except for Dabinett and Kingston Black, the varieties do not differ significantly in their average specific gravities. It is common experience that the specific gravity of apple juices is influenced much more by seasonal factors than by variety, although the later-ripening varieties such as Dabinett tend to give higher gravities.

Since most of the varieties in the table are bittersweets, their tannin contents are of particular interest. It has long been recognized that the determination of tannin by permanganate titration (3) is only an approximate measure of the bittersweet character of a cider (4). The discrepancy between tannin titration and bittersweet flavour is well illustrated by the varieties Dabinett and Yarlington Mill. The former is recognized as a full bittersweet variety while the latter is only a medium bittersweet ; yet the average tannin contents of their juices are 0·29 and 0·32% respectively.

This apparent inconsistency can now be explained. The permanganate-reducing power of apple juice is due mainly to the presence of *ortho*dihydroxyphenolic substances. These can be divided broadly into (a) chlorogenic acid, which has very little bitter or astringent flavour and (b) leucoanthocyanins and catechins which are mainly responsible for the tannin flavour. It is now known (5) that Yarlington Mill contains much more chlorogenic acid than does Dabinett, so that its tannin titration is higher than would be expected from its bittersweet flavour. Although this limitation of the permanganate method must always be recognized, most varieties contain less chlorogenic acid than does Yarlington Mill, so that their permanganate titrations are correspondingly more reliable as estimates of tannin.

The juice analyses quoted in this paper should be of assistance in deciding what varieties should be planted to meet the future needs of the cider industry. But some regard must also be paid to cider-making experience in assessing qualitatively the bittersweet character of a variety.

Acknowledgment.

The author is grateful to Mr. G. M. Clarke for the statistical examination of the juice analyses reported in this paper.

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THE CONTINUOUS EXTRACTION OF JUICE FROM CIDER APPLES

By F. W. BEECH.

The conventional hydraulic press extracts juice very efficiently from apple pulp, but it has some drawbacks in large scale production. It can press less than 3 tons pulp per hour, it produces juice intermittently and requires a minimum of 2 men at each cheese building station. Normally, seasonal labour is employed to operate the press. If the workers are inexperienced, maximum juice yields are not readily attained, as the press cloths break if not packed uniformly with pulp. A number of cider makers are already finding it difficult to get temporary labour for this unpleasant work. Admittedly the clover leaf press is more economical in manpower, but it still retains many of the undesirable features of its predecessor. The use of cloths has in itself certain disadvantages : they become heavy and unmanageable when wet with juice and, unless washed frequently, can contaminate the cider with micro-organisms (1, 2).

Some form of continuous and automatic press could have many advantages. There are several continuous extraction machines that can be used for processing soft fruit pulps, but none has proved completely satisfactory for apples (3, 4). However, there are others, designed originally for de-watering a variety of raw materials, that show promise. After some preliminary trials in the 1960-61 season, two of these machines, a roller press and a pulp centrifuge, were selected for more detailed tests in the 1961-62 season. It must be emphasized that neither was developed originally to process apple pulp and that both will need modification.

Experimental.

The roller press is a drum, covered with a wedge wire screen, that rotates on its horizontal axis. Pulp passes from a hopper, under two subsidiary rollers, and is discharged continuously. The juice passes through the screen and is pumped away from a juice-collecting trough. The pulp centrifuge is essentially a vertical conveying cone rotating in a slotted basket, to which an interchangeable screen is attached. The pulp is pumped into the top of the cone and the juice is flung off through the screens, which are kept clean by a small difference in the rotational speeds of the cone and basket. The solids fall through the main housing to be discharged at the base.

Sweet Alford and Stoke Red were the two contrasting apple varieties used for the test. The first gives a rather pectinous pulp, difficult to press : the second has a firm crisp flesh and gives up its juice very readily.

The washed fruit was milled and the pulp pumped to either machine or to a hydraulic press. The weight of pulp processed was calculated from the combined weights of juice and pomace obtained, after making sure that no pulp, juice or pomace was retained in the equipment. The cloths and racks of the hydraulic press were weighed before and after pressing, so that a correction could be made for the amount of juice held in them. An approximation to the wet weight of suspended solids was obtained by centrifuging 100 ml. of juice and re-weighing the centrifuge bottle after decanting the liquid and allowing the bottle to drain for a standard period.

Results.

It is impossible to define the precise period when an apple is " mature " : the metabolism of the fruit continues throughout storage and in any pile of apples there is a gradation from mature to overmature. Eventually most of the fruit becomes overmature and pressing difficulties begin. It was not possible to complete all the tests in a short time, and with fruit at a given state of maturity. Hydraulic pressings were therefore made at the beginning and end of the " mature " period to give an indication of the changes taking place in the fruit. Tests on overmature fruit were completed within 21 days.

Effect of pulp particle size

A conventional grater mill does not produce pulp of uniform particle size ; as it becomes worn, it produces a greater proportion of relatively large particles (up to 2" long). The importance of particle size was illustrated by feeding the roller press with $\frac{1}{4}$" apple cubes ; only 2 or 3 drops of juice were produced from 1 cwt. of this material. Therefore, the yield of juice is influenced by the nature of the pulp put through this machine, and the same consideration would apply to the centrifuge and hydraulic press. It is hoped to examine next season the effect of pulp particle size on pressing efficiency.

Yield of Juice.

Mature Fruit. Juice yield can be expressed either as the number of gallons produced per ton of fruit or as the percentage yield by weight, the method used in the present tests. There is a numerical relationship between these two values :

Gallons per ton = K × Percentage yield by weight.

$$K = \frac{2240}{\text{Sp. gr.} \times 1000}$$

(In these experiments the average value for K was 2·1575)

The yields of juice obtained from first pressings are given in Table I.

TABLE I.

YIELDS OF JUICE FROM FIRST PRESSINGS OF MATURE FRUIT.

(Percentages by weight)

Press		Sweet Alford		Stoke Red	
		Throughput tons/hour	Juice yield	Throughput tons/hour	Juice yield
Hydraulic.	Start of test	1·2	68·6	1·6	74·1
Roller.	Slowest speed	1·0	48·5	1·1	55·3
,,	Fastest speed	1·4	47·1	1·7	59·5
Centrifuge.	Coarse screen, low throughput ..	1·3	56·5	1·5	53·1
,,	,, ,, fast throughput ..	5·0	49·8	—	—
,,	Fine ,, ,, ,, ..	4·4	49·8	4·4	58·9
Hydraulic.	End of tests	1·6	74·3	1·6	80·8

The hydraulic press obviously gives the greatest juice yield, and this increases with increasing fruit maturity. As was expected from the character of its pulp, the greater yield of juice was obtained from Stoke Red which, unlike Sweet Alford, also gives a higher yield with the faster throughput.

The pomaces from the two machines clearly contained at least another 20% extractable juice. They were all pressed a second time on the hydraulic press; they gave the *combined* yields from first and second pressings shown in Table II.

TABLE II.

COMBINED YIELDS FROM 1ST AND 2ND PRESSINGS OF MATURE FRUIT.

(Percentages by weight)

Machine for 1st Press : 2nd Press hydraulic	Sweet Alford	Stoke Red
Roller Press. Slowest speed	75·5	82·7
,, ,, Fastest speed	75·1	81·1
Centrifuge. Coarse screen, slowest speed ..	77·7	82·6
,, ,, ,, fastest speed ..	78·2	—
,, Fine screen, fastest speed ..	79·0	83·4
Hydraulic press, end of tests	80·2	85·8

The double hydraulic pressing gave a slightly greater yield than any combination of continuous and hydraulic press. Again pressings of Stoke Red gave a 5% better yield than Sweet Alford. With the latter variety the combination of centrifuge and hydraulic now gave a slightly better yield with finer screen and faster throughput.

Overmature fruit. The yields from both the first and combined pressings of Sweet Alford on the roller press were increased when the fruit was overmature, whereas the corresponding yields from the hydraulic press were reduced. There was no difference between the yields from mature and overmature Stoke Red pressed hydraulically.

TABLE III.

YIELD OF JUICE FROM OVERMATURE FRUIT.

(Percentages by weight)

Press	Sweet Alford		Stoke Red	
	First pressing	Combined first and second pressings	First pressing	Combined first and second pressings
Hydraulic	73·1	78·8	78·9	85·3
Roller. Fastest speed	53·4	77·6	48·3	81·2

The considerable reduction in yield from roller-pressed Stoke Red pulp was due to the sieves on the roller becoming blocked. This may have been caused either by the Stoke Red pulp or by the Sweet Alford which had been put through the roller immediately before the Stoke Red. On second pressing, the combined yield was the same as for mature fruit.

Suspended Solids.

Juice from a hydraulic press is usually very clear, being strained through the mass of pulp within the press cloths ; continuous presses lack this advantage. The amount of suspended solids in a juice is important, since they carry the oxidizing enzymes which cause the juice to darken very rapidly—a change undesirable in unfermented products. The oxidation effect is of less importance in cider making, but here the presence of the suspended particles themselves is a disadvantage, for tank capacity is wasted by an excessive volume of lees.

The hydraulic press yielded juices with very low suspended solids, ranging from 0·1 to 0·2 grams wet weight per 100 ml. Juices from the roller press, and from the centrifuge run with the finer screen and highest throughput, contained twenty times as much suspended solids ; even greater values were obtained when the centrifuge was run at slower speeds.

Discussion.

A hydraulic press produces a high yield of juice with a low suspended solids content ; furthermore, there is a 50 per cent reduction in the tannin content of the second-pressed juice. The characteristics of the continuous machines were opposite in two respects, viz., low efficiency and high suspended solids, with only slight reduction in tannin. These differences between the machines are caused by the manner in which pressure is applied to the pulp. The cheese is in a hydraulic press for 20 to 30 minutes and for at least half this time the pulp drains freely ; only then is pressure gradually built up. With all the continuous machines so far proposed for cider making, full pressure is applied immediately. Consequently there is no time for a "filter bed" to be built up within the mass of pulp, so that the fine particles pass out in the juice stream. This is particularly noticeable with other types of press that use a continuous press cloth. Whatever material forms the band, it soon "blinds" by becoming impregnated with these particles.

Continuous machines have two outstanding advantages. The first is the reduction in the number of men needed to operate them and the second is their ability to run uninterruptedly. In a factory equipped with such presses, pulp could be supplied in a ring main, juice and pomace being removed continuously. The whole process could be controlled automatically and only shift mechanics would be needed for supervisory work. Already there are continuous juice installations using a centrifuge, followed by a screw press, the combined juice being clarified with a pre-coat vacuum filter (5, 6). The disadvantages already enumerated are considered to be counterbalanced by the advantages of continuous production, lower labour charges and the increased standard of hygiene that becomes possible.

It is unfortunate that no one has made a rheological examination of apple pulp to find out how it releases juice under pressure. With this basic information it would be possible to design a machine that extracted juice with maximum efficiency. While it is cheaper to modify machines already in existence it is doubtful whether the perfect machine will ever be produced without this basic research.

Summary.

The performance of two prototype machines, capable of producing apple juice continuously, was compared with that of a conventional hydraulic press. The yield of juice from both was less than that from the hydraulic press and the content of solids suspended in the juice was higher. Further development of the continuous machines is justified because of their great advantages of increased output and economy of operating labour.

Acknowledgment.

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THE EXAMINATION OF DOMESTICALLY FROZEN FOODS: I. STANDARDIZATION OF A BACTERIOLOGICAL COUNTING METHOD.

By M. JEAN DAVEY and ANGELA M. NEWBERY.

A considerable amount of information is available on the microbiology of commercially frozen foods, but no comparable work has been carried out on foods frozen in the home. An investigation of the microbiology of home freezing is therefore being made to determine the changes brought about during preparation, freezing and thawing.

The first stages of the investigation have been concerned with the standardization of a method suitable for the routine determination of viable organisms in food samples. The method needed to be rapid, of measureable accuracy, and able to allow easy isolation of representative organisms for further study. The last qualification excluded the use of most probable number or roll-tube techniques, and made unsatisfactory the usual pour-plate method, which is also laborious. A surface drop count method, which was rapid and simple enough to allow adequate replication of experiments, was therefore adopted, using Dreyer pipettes.

As the viable-count results were to be used as a basis for the whole project, the pipettes were calibrated in order to determine statistically the limits of accuracy of the counting method.

Experimental.

Two basic calibration methods were applied to each of 34 pipettes. In the first method the size of drop delivered by each pipette was determined accurately by weighing; in the second, colony counts per drop of a standard suspension of bacteria were used to estimate variations in drop size. Following the recommendations of Straka & Stokes (1) 0·1% peptone water was used as a diluent to keep surface tension, and therefore drop size, constant during the calibrations.

Calibration Method I

1 ml. of the 0·1% peptone water was measured with a Grade A bulb pipette and weighed accurately. This was repeated to give six replicates and the average weight calculated for use as a standard. A Dreyer pipette was then held vertically in a clamp and twenty drops, theoretically 1 ml., were delivered into a weighing bottle at a controlled rate of one drop per second. The volume was weighed accurately and the procedure repeated to give six replicates for each pipette. The whole experiment, including the preparation of a standard, was carried out separately by two operators, to permit calculation of error due to variation between operators, as well as between pipettes.

Calibration Method II

A pure culture of a test organism (*Staphylococcus epidermidis*) was inoculated on nutrient agar slopes, which were incubated at 37°C overnight. The resulting growth was washed off with 0·1% peptone water; the suspension was then diluted with peptone water to a faint turbidity, and decimal dilutions

of 10^{-5}, 10^{-6} and 10^{-7} were prepared for counting. Two operators worked at the same time, using the same dilution bottles of suspensions and exchanging pipettes. The pipettes were held vertically and drops delivered at a controlled rate, as before. The drops were allowed to fall on to the surface of nutrient agar in standard 10 cm. petri dishes. Before use, the agar plates were dried open at 37°C for 4–5 hrs., and stored closed at room temperature overnight. A maximum of four inoculations could then be made on each plate, drying rapidly enough to prevent the drops becoming confluent. Three plates, giving twelve replicates per operator, were used throughout. As soon as the inoculations had dried, plates were inverted and incubated at 37°C for 18–24 hr., after which the colonies were counted and the variance in the figures was analysed.

The total of 34 pipettes was divided into two groups and the groups were calibrated separately in sections A and B of the experiment. Calculations could thus be made of variations within individual pipettes, between different pipettes and between operators, all other factors remaining constant in each case.

Results.

Drop weighings. For each pipette the mean weight of 20 drops lay within the range 0·8488g. to 1·0199g., compared with the standard 1 ml. weighing 0·9942g. Assuming the stated factor of 20 drops per ml. only 7 of the 34 pipettes were not significantly different from the standard at the 5% level. A further 10 pipettes could be brought within this limit of accuracy by using a factor of 21 drops per ml. The remaining 17 pipettes delivered drops of intermediate size.

When pipettes were listed in ascending order of drop size for each operator separately, it was found that, despite slight variation between the sets of results for the two operators, the order of pipettes was approximately the same.

By this method, when twelve replicates were used, the 95% confidence limits for mean drop weight were :

$$\text{Observed Mean} \pm 2{\cdot}5\%$$

Colony Counts. From preliminary tests it was found that plates with 20 to 80 colonies per drop were easy to count and gave consistent results. Dilutions giving counts within this range were therefore used, and the results analysed as before.

Variation between replicates from individual pipettes was high, and there were consequently few significant differences between the pipettes. In section B of the experiment the difference between operators was significant at the 0·1% level, but in section A the difference was not significant. Throughout the experiment, however, significant differences were found between the total counts from each of the 3 replicate plates for each pipette.

All the results for both operators in both halves of the experiment gave 95% confidence limits for the mean drop count which were :

$$\text{Observed Mean} \pm 10\%$$

In some work with vegetable samples a dilution of at least 10^{-1} was needed to give a suspension which could be pipetted conveniently. Under these circumstances counts of 0 to 10 colonies per drop were found to occur

frequently. An analysis was therefore carried out of a calibration experiment giving results within this range. The total error was found to be considerably larger : 95% confidence limits for mean drop count in this case were :

Observed Mean $\pm 28\%$

Discussion.

The weighing experiments showed that only half the pipettes examined delivered accurately 20 or 21 drops per ml., and in very precise work it would be advisable to use only these. In the present work, however, the error in colony counting is relatively large and it seems unnecessary to consider the small contribution made by the variation between pipettes, as determined in the weighing experiments.

In the colony counting experiments, variation between operators contributes only slightly to the total error : differences between replicate plates are thought to be due to settling of suspended organisms in the pipettes, or to disturbances of working position and rate during the changing of inoculated and un-inoculated plates. It is hoped that these errors will be reduced as more experience is gained in the technique.

Increased error in counting small numbers of colonies per drop was probably caused mainly by greater error in sampling from a suspension containing very few organisms, and to a lesser extent by error involved in rounding off numbers to one significant digit. In these circumstances it is possible to give only an approximate estimate of organisms in the original suspension. The error shown in counting fairly large numbers of colonies (20 to 80 per drop), however, compares favourably with results obtained by Pomales-Lebron and Fernandez (2) using a surface drop count method, and Pikulska (3) and Snyder (4) using drop, pour-plate and roll-tube techniques.

Summary.

The overall error in counting micro-organisms by a surface drop method is 10% of the mean value provided that there are approximately 20 to 80 colonies per drop. Where there are less than 10 colonies per drop, the error becomes much greater.

Acknowledgments.

We are indebted to the Statistics Section for the analysis of the experimental results.

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A NOTE ON COVERS FOR VINEGAR PRESERVES

By MARGARET LEACH.

Most pickles and chutneys need time to mature and are therefore likely to be kept longer on the shelf than other preserves. The tendency for vinegar to evaporate makes the choice of a suitable cover important. Home-made vinegar preserves of good quality may deteriorate on storage if the covering is faulty. As this type of preserve is generally inexpensive to make, there is natural reluctance to purchase special covers unless they are reasonably priced. In a previous test (1) two metal, two plastic and four parchment covers were used. In the present series a further range of covers has been tested.

Experimental.

Vinegar.

The evaporation of vinegar under synthetic fruit preserving skin was compared with the loss under a standard metal cover used in the previous tests (1). For each type of cover, five jars were filled with a weighed amount of vinegar of 4·5% acetic acid content. Covers were put on at once. Losses in weight were determined after the jars had been stored at 25°C for 17 weeks, and again after a further 43 weeks. After 17 weeks the loss of acetic acid was also determined.

The covers used were :

(a) *Standard.* Metal with ceresin-lined disc : 4-lug lacquered metal with an inner disc of waxed cardboard and a ceresin vinegar-resistant layer, made for use with straight-sided pickle jars.
(b) Synthetic skin tied with layered string over a ½ lb. jam jar filled with cold vinegar.
(c) As (b) but vinegar heated to 93°C before pouring into jar.

TABLE I.

VINEGAR : LOSS OF WEIGHT AND ACETIC ACID AFTER STORAGE AT 25°C.

Cover	Loss of weight %				Loss of acetic acid in 17 weeks % original content of jar
	After 17 weeks Mean	Range	After 60 weeks Mean	Range	
(a) Metal Cover : ceresin liner	1·0	0–2·1	9·5	1·1–21·1	nil
(b) Synthetic skin over cold vinegar	3·4	2·4–4·3	31·8	19·6–36·6	7·2
(c) Synthetic skin over vinegar at 93°C when bottled	3·8	2·1–5·0	22·9	11·9–34·6	15·4

Chutney.

For measuring the evaporation of chutney, each type of cover was tested by filling three or four jars with a standard apple chutney and covering hot. A headspace of ½″ was left in each jar, except with cover (c), with which the

jars were completely filled. Covers (d) and (e) were momentarily raised at one side to expel hot air two minutes after filling. One jar with a cover of each type was stored at 3°C and the remainder at 24°C for 27 weeks.

The covers used are shown in Table II.

Covers (a) to (c) were made for use on screw-top pickle jars ; covers (d) to (f) for use on jam jars. Cover (b) is similar to cover (d) used in the 1958 tests (1).

TABLE II.

CHUTNEY : LOSS OF WEIGHT AFTER STORAGE FOR 27 WEEKS.
(per cent)

Cover	Stored at 2°C	Stored at 25°C	
		Mean	Range
(a) Rigid plastic screw cap with ceresin disc	nil	1·00	0·72–1·46
(b) As (a) but with waxed cardboard disc instead of ceresin	0·12	2·80	2·57–3·22
(c) Lacquered metal screw cap with Cerowad liner	0·43	1·57	1·20–2·02
(d) Pliable plastic press-on cover with ceresin disc	nil	1·65	1·14–2·14
(e) As (d) but without ceresin disc	0·32	0·54	0·30–1·31
(f) Lacquered metal press-on cap with Cerowad liner	0·36	5·39	4·37–6·05

Ripe Tomato Sauce.

With tomato sauce, a preserve that requires heat processing after bottling, seven methods of sealing were tested, with 3 or 4 replicates, using a standard ripe tomato sauce recipe. Standard 7 oz. sauce bottles were inoculated with mould ; hot tomato sauce was poured in, leaving a 2″ headspace. Covers were fitted and the bottles heat processed, after which the covers were adjusted as required. The outside of the completed seals was inoculated with mould the following day and all bottles were stored at 25°C for 27 weeks.

The seals used were :

(1) Corks—tied on during processing.
  (a) paraffin waxed as soon as cool enough after processing to hold wax.
  (b) waxed next day.
(2) Corks and screw caps.
  (a) processed in position ; screw cap lightly attached and tightened directly after processing.
  (b) cork tied during processing and screw cap put on tightly directly after processing.
  (c) cork tied during processing ; screw cap put on next day.
  (d) cork tied during processing ; waxed as soon as cool enough to hold wax, and screw cap fixed over warm wax.
  (e) cork tied during processing ; screw cap put on directly after processing and waxed as soon as cool enough to hold wax.

Two further seals were tested using the cork and screw cap (2(a) above),

for comparison. The same recipe and processing were adopted. Five replicates were prepared and were stored at 25°C for 11 weeks.

(1) Lacquered metal screw cap with ceresin disc.
(2) Cork and screw cap (2a above).
(3) Lever-topped bottle with earthenware stopper and rubber gasket.

Results.

Vinegar.

The results are shown in Table I. It will be seen that losses both of weight and acetic acid were greater with the synthetic skin than with the lined metal cover. With all covers the rate of evaporation was greater in the second period of storage than in the first. Owing to its relative cheapness and its adaptability for covering non-standard jars, the synthetic skin could be used for short term storage. It was shown in the previous tests (1) that, with all types of cover then used, the rate of loss of weight from vinegar exceeded the rate of loss from chutney and it is therefore fair to assume losses smaller than those here recorded when using synthetic skin for covering chutney.

Chutney (Table II).

It will be seen that with all types of cover losses were negligible in jars stored at 2°C : losses were much heavier at the higher temperature. Lacquered metal covers for jam jars (f) showed the greatest loss (5·39%). The pliable plastic cover without any liner (e) showed the least loss (0·54%) ; the same cover with a ceresin disc (d) showed a loss of 1·65%. The plastic screw cap with ceresin disc (a) showed a loss of 1·00% whereas the same cover with a thicker disc of waxed cardboard had a loss of 2·80%.

Where storage temperatures of 2°–4° are available, any of the covers tested could be recommended. Domestically, cold storage is not usually available. For normal room temperatures, the most satisfactory covers in the present series are : for jam jars, pliable plastic without a liner ; and for screw jars, rigid plastic with ceresin disc or lacquered metal cap with Cerowad liner. It will be found that the first two of these covers compare very favourably with covers tested previously (1).

Ripe Tomato Sauce.

On examination after storage, no mould was found on any sauce, but with (1a) there was heavy mould on one cork and with (2c) slight mould on one cork. This mould had not penetrated into the bottle in either case. There was no appreciable shrinkage or loss of quality but all sauces showed some discoloration. This was very marked in (2a) and (2c) and slight in (1b) and (2d).

In the further test there was no mould and no apparent shrinkage. Slight discoloration was discernible throughout.

Ripe tomato sauce must be sealed after processing. The present tests cover the variants of the methods of sealing generally recommended. All were found to be effective. As corks and paraffin wax are not normally available in the home, the use of a suitably protected screw cap, such as that used in the second test, may recommend itself. Some degree of discoloration is to be expected at the relatively high temperature used for storage.

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THE ROOTING PATTERN OF THE BASKET WILLOW —*SALIX TRIANDRA* VAR. BLACK MAUL— AT LONG ASHTON.

By K. G. STOTT.

Introduction.

Basket willows are often grown in soils in which the depth of rooting is adversely affected by a high or fluctuating water table, and it is generally held by growers that lateral rooting is important. A study of the rooting pattern was made primarily to determine the likelihood of damage to surface roots resulting from the use of mechanical cultivators to control weeds, but also because it is fundamental to the choice of spacing distance, length of cutting and depth of planting. Since hydraulic equipment was needed for excavating the plants, the investigation was made at Long Ashton though the site available was more freely drained and the soil more clayey than that of most willow beds.

Experimental.

The experimental plot measured 93 ft. × 27 ft. and occupied a site in the south east corner of the Research Station at an elevation of 100 ft. (1). The soil is derived from Keuper Marl with added colluvium and has been ascribed by Osmond (2) to the Worcester Series. The upper 6″ consists of brownish-red loam, overlying a heavy red clay. Below 3 ft. there is blue-grey powdery clay with some orange-yellow mottling. Drainage is moderately good, with a water table normally at or below 3 ft.

Four hundred uniform cuttings of *Salix triandra* var. Black Maul, 14″ in length, were planted in March 1954 to a depth of approximately 12″ at a spacing of 3 ft. × 3 ft.; good growth was made during the first season. They were then divided according to a statistical layout which provided 30 sets of samples, each of 8 root systems, 2 from each of 4 blocks. Three sets were taken in autumn 1954, 6 during the growing seasons of the years 1955, 1956 and 1957, 2 in 1958 and 1 each in 1959 and 1960.

The root systems were dug out in 1954 and 1955, but from 1956 onwards a pump delivering 350 lb. water p.s.i. through ½″ high pressure hose to a spray gun was used to wash the soil away. About 1,000 gall. were needed to extract the 8 plants taken in 1960.

The length of cutting below ground was measured and marked from ground level downwards into zones 0–3″, 3–6″ and below 6″. Roots originating in each zone were counted, severed and dried to constant weight. Measurements were also taken of the diameter of the cutting at its base and at ground level, and of the longest root and its point of origin. The mean annual values are given in Table 1, with an indication of the level of significance. A photograph was taken of the root system most representative of each sample (Plate XIII).

Results.

In the first season each cutting produced about 50 roots evenly distributed throughout its length, but slightly more numerous near the nodes (Fig. 1). Root systems sampled in 1954–56 were characterized by the absence of main

roots in the surface 3″, by laterals produced at a depth of between 4 and 8″, and by positively geotrophic basal roots produced at a greater depth (Figs. 4, 5, 6). As growth progressed, an increasing proportion of the root system was represented by lateral roots, and rooting at a depth of about 3″ became more extensive.

Most laterals ran horizontally at a depth of about 6″ but sometimes they were produced near the base of the cutting and were traced for over 5 ft. at a depth of 12″ (Figs. 6, 9). They tended to pursue a straight course but exceptions were found where the root bent laterally through an angle of 80° or even 180°. Occasionally roots were produced near the base of the cutting and ran upwards before continuing horizontally in shallower soil.

Root systems taken before 1958 were generally symmetrical with 3 or 4 laterals of the same length (Fig. 3) ; systems 3 ft. in diameter were found in 1955 and up to 17 ft. in 1957. In later samples one long lateral often predominated (Fig. 8) and many over 7 ft. were found ; in 1960 the longest measured 12 ft.

Lateral roots tended to branch and be more fibrous than basal roots (Fig. 7), many of which descended unbranched to below 3 ft. Occasionally lateral roots, or more frequently their branches, turned vertically downwards into the subsoil.

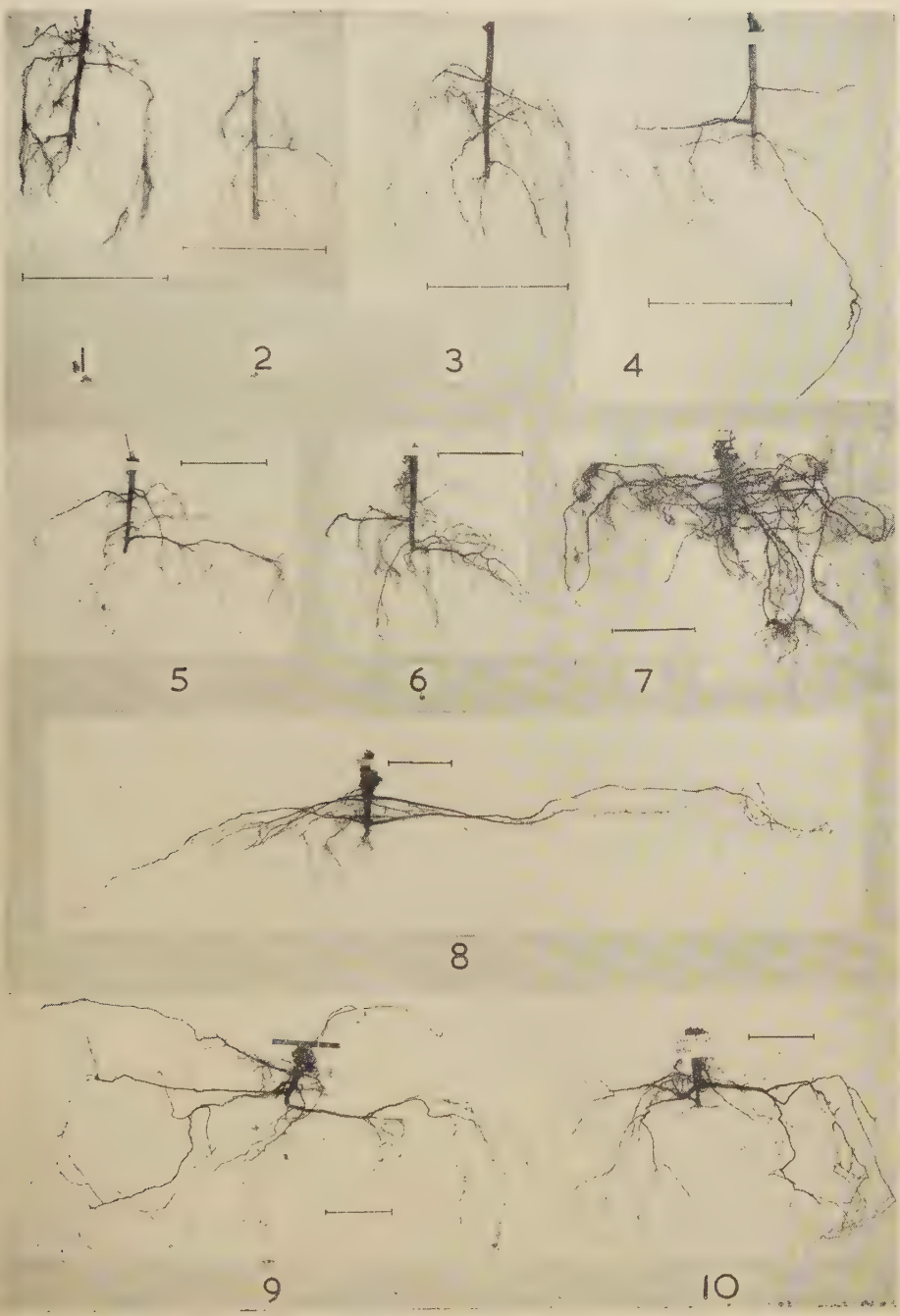
Discussion.

The mean weight of roots and the diameter of the cutting at ground level, shown in Table I, give a good indication of the growth of the root system in the first 6 years. No significant increase was found in 1960, the seventh year, and the experiment was then abandoned. At this stage it was difficult to extract the root systems without damaging the roots of surviving plants and the site had become very uneven because of the upheaval of large quantities of soil. Soil tended to accumulate round the cuttings or to be eroded away, introducing errors into the method of assessment which led to large variations in the values obtained for the surface 3″ zone in later years.

It was often found that cuttings had died below the point of origin of the lowest root and Table I shows that in 7 years the length of rooted cutting decreased by 1″ and that only a small increase in basal diameter was made. These observations suggest that a valuable saving of planting material could be made by using shorter (10″) cuttings inserted to a depth of 8″.

In willows adventitious roots are derived from root initials lying outside the phloem ; these are more numerous near the nodes (2). Young roots were thus distributed around every node on the cutting. Nearly all of them were produced in the first year and, though many grew no more than 1″, they persisted for about 3 years. Table I shows that it was not until the fourth season that a significant decline in numbers was observed. As the total number of roots fell, the proportion in the basal 6″ decreased significantly. This decrease was not reflected in root weights, indicating that the changes were due to the death of small roots of little consequence.

The dominant role played by lateral roots was emphasized by the length they attained during the investigation ; examples 4½ ft. long were found in the first year, and up to 12 ft. in the final year. Most laterals penetrated root systems of other plants and, during extraction, damage to one or more plants



Willow root systems sampled : *Fig.* 1, 2.9.54 ; *Fig.* 2, 19.5.55 ; *Fig.* 3, 21.6.55 ; *Fig.* 4, 30.9.55 ; *Fig.* 5, 15.7.56 ; *Fig.* 6, 16.8.56 ; *Fig.* 7, 10.9.57 ; *Fig.* 8, 5.11.57 ; *Fig.* 9, 30.9.59 ; *Fig.* 10, 3.10.60.

The scale represents 1 foot.

TABLE I.

GROWTH AND DISTRIBUTION OF ROOTS ON WILLOW CUTTINGS

Mean annual values

	1954	1955	1956	1957	1958	1959	1960
No. of root systems sampled	24	48	48	48	16	8	8
Length of rooted cutting (in.)	11·4	11·8	11·1	10·8	10·6	10·2	10·3
Diameter of cutting (in.) at base	11·4	11·0	11·5	12·3	12·0	17·1	18·8
Diameter of cutting (in.) at ground level	14·4	15·9	22·6	38·0	50·6	60·3	57·5
Length of longest root (in.)		22·9	44·3	66·4	85·1	96·8	85·6
Depth of point of origin of longest root (in.)		6·9	6·2	6·0	6·0	5·9	5·5
Dry weight of root system (g.)	6·8	8·9	37·9	119·9	275·6	415·1	318·9
Dry weight (%) in zones :							
0–3″		12·0	19·2	24·8	30·9	18·3	27·9
3–6″		38·7	35·2	33·6	29·4	43·3	31·1
0–6″	60·4	50·7	54·4	58·4	60·3	61·6	59·0
>6″	39·6	49·3	45·6	41·6	39·7	38·4	41·0
No. of roots originating from the cutting	49·9	51·7	54·3	48·2	41·1	31·6	25·8
No. (%) in zones :							
0–3″		18·5	19·9	26·3	38·7	37·7	36·7
3–6″		20·0	25·1	25·1	22·1	31·2	24·8
0–6″	41·4	38·5	45·0	51·4	60·9	68·9	61·5
>6″	58·6	61·5	55·0	48·6	39·2	31·1	38·5

* Figures significantly different from those of the previous year (or a different rooting zone) at the 5% ; ** at the 1·0% ; *** at the 0·1% level.

was unavoidable. It is for this reason that assessments of mean length of longest root show no significant increase over the value of 7 ft. recorded in 1958.

Though a spacing of 27 or 24″ × 14″ is used in most commercial willow beds, a spacing of 3 ft. × 3 ft. was used here to ensure unrestricted root development in the early years. The space available to each system was 9 sq. ft. at the time of planting, but it increased as samples were removed, and by 1957 areas as large as 100 sq. ft. had been left vacant. Even though large roots established themselves in these spaces, many root systems overlapped, and it must therefore be assumed that root competition at the close spacings employed in commercial beds must contribute greatly to growers' experience that the yield from a willow bed falls after the seventh year.

The mean depth at which the longest lateral occurred throughout the experiment was 6·2″. In general most rooting occurred between 4 and 8″ : only rarely were strong roots produced from the base of the cutting. The root systems showed regular significant increases in weight up to the seventh year. These increases were evenly apportioned between the zones above and below 6″ with the result that the proportions in the two zones, 60 and 40% respectively, were the same in 1960 as in 1954. This consistent difference is highly significant when averaged over the seven year period. During the first four years the proportion of roots in the surface 3″ was significantly lower than that in the 3–6″ zone and although it had doubled during this period it had reached only 28% by the seventh year. Mechanical cultivation to a depth of 2″ is therefore not likely to injure roots, particularly in the early years of establishment when weed control is most important.

Acknowledgments.

I wish to thank Mr. T. W. Cox for his help in excavating and recording the root systems, members of the Photographic and Statistics Sections for their assistance, and Professor H. G. H. Kearns for his interest and advice.

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THE APPLICATION OF DALAPON FOR THE CONTROL OF GRASSES IN WILLOW BEDS AND ITS EFFECT ON SOME WEEDS.

By K. G. STOTT.

Introduction.

Basket willows are grown as annual coppice shoots from permanent stools at a density of about 17,000 stools per acre. Cuttings are planted in rows 24-27″ apart in well-cultivated ground, which in Somerset is readily colonized by annual weeds, grasses and a number of common herbs. These follow a succession in the establishment of many beds : creeping buttercup is dominant in the second or third year after planting and is followed by grasses (*Agrostis* spp). The larger weeds, meadowsweet, nettle, comfrey, docks, bindweed and brambles, become abundant after about 15 years.

If left unchecked the grasses form a thick matted sward which in spring has a detrimental shade effect on the young willow shoots. Besides interfering with light, the larger weeds compete for available nutrients through their extensive root systems : they are one of the main causes of the degeneration of beds approaching 30 years of age : well-tended beds will often give economic yields up to their fiftieth year.

Weeds also interfere with harvesting. Willow rods are cut annually by hand sickle ; several are cut together and gathered into bundles. A special weeding is necessary in the autumn to free the stools, otherwise grasses and rushes make cutting difficult and add unwanted bulk to the bundles. Sorting weedy bundles is both tedious and uneconomic.

The importance of weeding, particularly during the establishment of the bed, has long been recognized (1, 2, 3). It was formerly carried out entirely by hand hoeing, but conditions during the 1930s led growers to find cheaper methods. Hoeing was retained only for the period of establishment ; beds were then allowed to revert to grass, which was cut two or three times a year with a hand sickle (1).

Since 1946 hand hoeing has been largely superseded by the use of small power-driven cultivators, but the final and most important weeding between the stools in the rows still has to be done by hand. In recent years labour has been scarce and so costly that weed cutting has represented the largest single item of annual expenditure.

Preliminary trials with a number of selective weed-killers were begun at Long Ashton in 1956. Willows proved highly sensitive to phenoxyacetic acid derivatives and no results of any promise were obtained until dalapon was tried in 1958. After successful trials of 4, 7 and 10 lb. active material/100 gall./acre at Long Ashton in 1959, a field trial using two rates of application was made on a commercial willow bed in 1960. This was followed in 1961 by an experiment to study the effect of time of application.

Experimental.

Layout and Treatments. The experiments occupied part of a Somerset willow bed, planted in 1958 to *Salix triandra* var. Black Maul at a spacing of 26″ × 14″. The soil is a silty clay overlying peat at 18″, neutral in reaction

and belonging to the Midelney Series (4). In the autumn following planting the bed was allowed to " tumble down " to grasses and herbs ; it was hand weeded three times in 1959. From 1960, in accordance with normal Somerset practice, cattle were allowed to graze the bed for a fortnight between mid-April and mid-May.

Rate of Application (1960). An area of 108′ × 65′ was divided into 9 randomized blocks, each of two half-blocks, to test the effect of mechanical harvesting on the shape and productivity of willow stools. Each half-block was then subdivided into three to give a control plot and one plot for each of two rates of application of dalapon. The plots were 12′ long and 5 rows wide and contained about 50 stools, of which 20, in the three centre rows, were available for sampling. They were guarded on the east and west by the outside rows, and on the north and south by two stools in each row.

A commercial preparation containing 85% by weight of dalapon (sodium αα-dichloropropionate), and incorporating a wetting agent, was used at 5 and 10 lb. of active material/150 gall./acre. The spray was applied to both willows and vegetation with a 3-nozzle hand lance at 28 p.s.i. flow pressure on 17 May, a week after the cattle had been removed. A mean of 10 willow shoots, 5½″ in length, was present on each stool.

Time of Application (1961). An adjacent area of 96′ × 65′ consisting of 12 blocks, each of 4 plots similar to those in the first experiment, was taken. A lightweight lance and single nozzle, working at 25 p.s.i., was used to apply 5 lb. of active material/150 gall./acre. In each block, one plot was sprayed on March 22, one on April 19, one on May 23 ; the fourth plot was left unsprayed as a control. Weather conditions were favourable during and after spraying in March and May, but two hours of rain occurred four hours after spraying in April.

Records.

Willows. In each plot the number and length of shoots were measured on one stool, selected at random in each of two of the centre rows. In 1960 they were measured on 16 May (before spraying), 22 July and 10 October; residual effects were measured on 18 July and 12 December in 1961. In the second experiment measurements were taken on 18 July and 20 November 1961.

Weeds. The ground cover consisted mainly of grasses, creeping buttercup, silverweed and areas of dead vegetation. It was realized that it would be difficult to sample, as it was dense and its components ranged from rosettes to tall weeds like fleabane. To obtain information that would show the effect of treatments on grasses and creeping herbs in particular, the percentage area occupied by each species was recorded on 17 July 1960 and 28 July 1961 in the first experiment and on 31 July 1961 in the second.

A quadrat one foot square (5) was thrown between the rows ten times in each plot, giving a total of 540 throws in the first experiment and 480 in the second. Throws were restricted to the three centre rows in each plot and were distributed at random along the middle 8′ of each row. Only the uppermost plants were recorded; no attempt was made to stratify the vegetation and record the different layers separately.

The distribution of 63 species was recorded and the results for 15 were

selected for statistical analysis. With the large herbs extreme values (e.g. 0–10 or 90–100%) predominated and it was necessary to transform the percentages for statistical analysis. In Table II they have been transformed back to percentages for those species showing significant differences.

TABLE II.

DISTRIBUTION OF VEGETATION : PERCENTAGE AREA COVERED.

Treatment	0, 5 & 10 lb. dalapon/acre applied 17.5.1960						5 lb. dalapon/acre applied March, April, May, 1961					
Date Recorded	17.7.1960			28.7.1961			31.7.1961				Sig. Diff. at	
	0	*5*	*10*	*0*	*5*	*10*	*Nil*	*Mar.*	*Apl.*	*May*	*1% level*	*5%*
Dead	0.3	15.3	7.1	0	0	0	0.3	4.0	3.0	27.5		
	***3.2**	**23.0**	**15.4**	–	–	–	**3.1**	**11.6**	**9.9**	**31.6**	**7.4**	**5.6**
Bare	0.3	1.2	1.7	0.4	1.5	2.1	0.3	1.2	1.1	4.9		
	3.0	**6.4**	**7.6**	**3.6**	**7.1**	**8.4**	**3.2**	**6.3**	**6.0**	**12.8**	**3.1**	**2.3**
Bents	58.2	1.5	0.6	54.0	3.3	2.5	74.1	20.3	48.6	20.2		
	49.7	**7.1**	**4.3**	**47.3**	**10.5**	**9.1**	**59.4**	**26.8**	**44.2**	**26.7**	**9.7**	**7.3**
Yorkshire fog	0.6	0.3	0.5	0.9	1.4	1.2	0.4	1.2	0.4	0.5		
	4.5	**3.2**	**4.0**	**5.5**	**6.7**	**6.2**	**3.5**	**6.2**	**3.6**	**3.9**	**1.8**	**1.3**
Timothy	1.1	0	0	1.6	0.4	0.4	2.8	0.8	1.4	0.6		
	5.9	–	–	**7.3**	**3.4**	**4.0**	**9.6**	**5.2**	**6.8**	**4.3**	**2.8**	**2.1**
Soft rush	2.1	1.2	1.8	3.0	0.6	0.7	1.9	0.5	0.5	0.7		
	8.4	**6.3**	**7.6**	**10.0**	**4.5**	**4.9**	**8.0**	**3.9**	**4.1**	**4.8**	**2.4**	**1.8**
Creeping buttercup	9.4	35.2	34.2	3.1	53.5	40.5	0	1.0	0.3	0.7		
	17.9	**36.4**	**35.8**	**10.1**	**47.0**	**39.5**	–	**5.7**	**3.1**	**4.8**	**11.4**	**8.6**
Silverweed	4.0	8.8	13.9	3.6	9.4	10.7	3.5	10.1	3.6	3.4		
	11.6	**17.2**	**21.9**	**10.9**	**17.9**	**19.1**	**10.8**	**18.5**	**11.0**	**10.6**	**9.6**	**7.2**
Fleabane	3.1	0.9	3.8	6.2	2.4	8.9	2.4	15.5	14.5	8.0		
	10.1	**5.4**	**11.3**	**14.4**	**9.0**	**17.4**	**8.9**	**23.2**	**22.4**	**16.4**	**7.5**	**5.3**
Field thistle	1.0	2.4	2.6	2.1	3.3	4.1	0.9	2.1	1.1	2.8		
	5.8	**8.9**	**9.4**	**8.4**	**10.4**	**11.7**	**5.5**	**8.3**	**6.1**	**9.6**	**4.2**	**3.2**

*Percentages given in ordinary type, transformed values in bold type.

Results.

Willows.

In the first experiment, observations made on three dates in 1960 failed to show any evidence of spray damage to willow foliage, and measurements made in July and October showed that neither rate of application had had any significant effect on the number or length of shoots produced. This finding was confirmed in the following year.

In the second experiment, the first application of dalapon was made in

March before growth had started. The shoots were later grazed and the first measurement was made in July ; this showed that the shoots in plots sprayed in March were 3″ longer than those in other treatments, a result significant at the 5% level. This effect was still apparent in November, though no longer significant (Table 1).

TABLE I.

EFFECT OF TIME OF APPLICATION OF 5 LB. DALAPON PER ACRE.

Date of application	Number of shoots per stool		Mean length of shoot (in.)	
	18.7.61	20.11.61	18.7.61	20.11.61
Nil	11.6	10.0	37.2	48.3
March	11.5	10.7	**40.0**	51.9
April	12.9	12.0	37.3	48.7
May	11.9	11.2	36.5	50.3

Figures significantly different in heavy type.

Weeds.

In 1960 browning of the vegetation was noticed a fortnight after the application of dalapon, and throughout the first season differences between plots receiving 0, 5 and 10 lb./acre were clearly visible. On untreated plots the grasses quickly recovered from grazing and grew vigorously to about 9″ by June and to nearly 2′ by the end of the season ; in the autumn the vegetation tended to collapse and bury the willow stools. In contrast, little grass grew on treated plots, but creeping buttercup and silverweed appeared to spread, becoming abundant the following year and forming in July a dense layer of vegetation about 8″ high. They died down in the autumn, leaving the stools and the base of the rods clearly visible for harvesting.

Applications of dalapon made in March and May 1961 had effects similar to those observed in the previous year, but only poor results were obtained in plots sprayed in April. The amount of vegetation killed was greatest in plots sprayed in May. Plots sprayed in March had a higher content of herbs.

The percentage areas covered by the main components of the vegetation are given for both experiments in Table II, together with the transformed values on which the analysis was carried out. A single set of significant differences, based on the pooled variance from all sampling dates, indicates the difference between transformed values that is required for significance at the 5% and 1% levels, and allows comparisons to be made of the effect of different treatments on the same or on different sampling dates.

Significant reductions in percentage area covered were recorded for soft rush, timothy and bents for all dates and both rates of application. Significant increases in growth occurred frequently in creeping buttercup, silverweed, fleabane and field thistle.

Discussion.

An attempt to measure the immediate effect of dalapon was made by recording the area covered by dead foliage and that devoid of vegetation (bare). Only 0.3% is normally dead in July but this was increased significantly by all applications of dalapon, the effect being least for the April treatment in 1961.

About 0.3% of the unsprayed area was bare in both years. Both rates of dalapon significantly increased the percentage of bare ground; the increase for the 5 lb. application in May 1961 was outstanding.

Grasses, mostly *Agrostis tenuis* and *A. gigantea*, covered about 60% of the surface; a very little Yorkshire fog (*Holcus lanatus*) and timothy (*Phleum pratense*) was present, but only trace amounts of other grasses were found. Both concentrations of dalapon were equally effective in killing almost all the *Agrostis* and timothy in 1960 and in checking their recovery in 1961. In contrast, Yorkshire fog was resistant to both rates and benefited from the death of other grasses.

Rushes, mainly soft rush (*Juncus effusus*), initially covered about 2% of both experimental areas. They turned brown in sprayed plots but did not rot away in the first season and remained as dead tufts which were scored when the vegetation was assessed. Consequently the reduction in area was not consistently significant in 1960, but in the second season the effectiveness of both concentrations was clearly demonstrated.

The area covered by creeping buttercup (*Ranunculus repens*) and silverweed (*Potentilla anserina*) more than doubled after treatment in 1960. Their distribution tended to be complementary: silverweed replaced buttercup in the second experimental area and in the adjacent blocks of the first experiment. Buttercup was abundant on the slightly higher ground near the ditch banks and sparse in areas where grass was prolific. The increase in silverweed was significant only with the 10 lb. application in 1960 and the March application in 1961.

Most other herbs formed only a fractional percentage of the total cover, but fleabane (*Pulicaria dysenterica*), thistle (*Cirsium* spp.) and nettle (*Urtica dioica*) were slightly more abundant, occupying 3.0, 1.0, and 0.5% of the total area. Had they responded to dalapon like buttercup or silverweed they would have been very troublesome at harvest time, but only slightly significant increases were recorded for plots receiving the higher concentration and for those sprayed in March.

Although no significant differences were observed between the two rates of application, the effects of time of application were marked. Table II shows that very significantly less bent and timothy was killed by the April application: this reflects the effect of rain in washing dalapon off the foliage.

Though buttercup and silverweed overran many of the treated plots, they died down at harvest time, leaving the ground almost bare, facilitating both hand and mechanical harvesting. Applications in May gave the best control of grass and the least growth of herbs, and combined well with the established practice of grazing willow beds in spring. After grazing, grasses and rushes grew vigorously and were very receptive to dalapon, whereas the willows were quiescent for about a week before new buds and shoots developed.

Summary.

The application of dalapon in March, April or May at 5 and 10 lb. of active material/150 gall./acre was shown to be without injurious effect on willow growth.

A very effective control of most grasses was given by both rates,

particularly of the bents which predominate in the wet neutral ground of Somerset willow beds. Yorkshire fog was resistant.

Applications in May combined well with the established practice of grazing willow beds and gave the best control of grass and the least growth of herbs.

A useful control of soft rush was achieved, though the effect was not always evident until the following season. Buttercup and silverweed increased to take the place formerly occupied by grasses, but they died down in the autumn leaving the ground and stools relatively clear for harvesting. Some of the larger herbs like thistle, nettle and fleabane showed a slight increase in treated plots.

In treated plots mechanical harvesting was greatly facilitated by the absence of clumps of rushes and of matted grass round the stools.

Annual applications of high rates of dalapon would kill a high proportion of grasses and encourage creeping buttercup and silverweed. To check grass growth and obviate the need for weeding it is recommended that 5 lb. of active material 150 gall./acre be applied in May, a few days after the cattle have been removed.

Acknowledgments.

I wish to thank Mr. T. W. Cox, Dr. J. H. Croft, and Mr. D. J. Reed for their help in recording, the staff of the Statistics Section for the design of the experiments and the analyses of the results, and Mr. L. F. Hector for permission to use his willow bed.

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TASTING TESTS ON BLACK CURRANTS AND STRAWBERRIES FROM FIELD SPRAYING TRIALS.

By G. M. CLARKE.

Crang and Clarke (1) presented the results of six years' tasting tests on strawberries taken from field spraying trials of common fungicides, and also on synthetic syrups containing the fungicides. Taints were detected in fruit used fresh or preserved by the usual methods. This paper presents the results of two further sets of tests carried out at Long Ashton : (a) from 1955 to 1961 on black currants from field plots sprayed with BHC, malathion, or lime sulphur ; (b) in 1960 and 1961 on strawberries from a field trial at the Luddington Experimental Horticulture Station in which fruit was sprayed with thiram alone or in combination with dinocap (Karathane) or lime sulphur.

Method.

Tasting was carried out on fresh fruit, on fruit preserved in a commercial-type deep-freeze unit, and on canned and bottled fruit, jams and syrups (black currants only) stored at room temperature for from three to seven months. The triangular tasting method was generally used, with a group or triangle of three samples consisting of two treated and one " control " (unsprayed) or vice versa : the difference between treated and control is assessed by the ease with which the odd member is picked out of the triangle. Members of the tasting panel scored fruit samples 0 (if no taint detected), 1 (slight taint) or 2 (taint), so that the nearer the average score for a sample approached 2 the more generally was it disliked. Taints may sometimes be assigned to the control samples, because of the effects of disease on the fruit.

Results.

BLACK CURRANTS

BHC.

	Strength and time of spraying	Sample	Months' storage	Taint
1955		Fresh fruit	—	None for (*a*), (*b*) or (*c*)
	(*a*) 0·007% at early grape	Frozen fruit	4	,, ,, ,, ,,
	(*b*) 0·014% at early grape	Canned fruit	4	,, ,, ,, ,,
	(*c*) 0·014% at advanced grape	Jam*	*	,, ,, ,, ,,
		Syrup	4	,, ,, ,, ,,
1956		Canned fruit	4	None
	0·00625% at advanced grape	Canned fruit	7	,,
		Frozen fruit	7	,,
		Canned fruit	4	Tainted, score 0·65
	0·0375% at advanced grape	Canned fruit	7	,, ,, 0·92
		Frozen fruit	7	,, ,, 0·85
1957	0 00625% at advanced grape (same bushes as in 1956, resprayed)	Fresh fruit	—	None
		Frozen fruit	4	,,
		Canned fruit	4	,,
	0·0375% sprayed in 1956 (examined for residual effect only)	Fresh fruit	—	None
		Frozen fruit	4	,,
		Canned fruit	4	,,

*Jam made from fruit which had been frozen for 4 months ; jam then tasted immediately.

Taint scores, except for the 0·0375% spray in 1956, were very low, never above 0·40. The triangular method was used in 1956 and 1957, but except where taints were observed there was no clear discrimination between the treated and control samples, the proportion of triangles correctly decoded being non-significant.

Malathion.

	Strength	Time of spraying	Sample	Months' storage	Taint
1957	0·075%	June	Fresh fruit	—	None
			Frozen fruit	4	,,
			Canned fruit	4	,,
			Jam	4	,,
1960	0·075%	June	Canned fruit	7	None
			Bottled fruit	7	,,
			Syrup	7	,,

The use of triangular tasting revealed no consistent taste differences ; in 1960 some tasters noted a colour difference between treated and control samples, but, although they could decode triangles correctly, they did not assign taints to any of the samples.

Lime Sulphur.

Between 1959 and 1961, lime sulphur sprays (mostly at 1%) were included in a number of trials, and fruit samples from these trials were tasted by the triangular method. Table I shows that the number of correct triangles was sometimes significantly high, preference for control over treated samples marked, and taint scoring high.

In 1959, most of the samples were considered tainted to some extent, the jam made from fruit sprayed at 1% being disliked more than the canned fruit. (No reason can be advanced, however, for the anomalous result obtained for the jam made from fruit which had received a 2% spray). Even when the number of correct triangles was not high enough to achieve significance, most of the correct ones gave preference to the control, and tasters' marks for taint were higher for all treatments than for the corresponding controls. Fruit sprayed six times (at fortnightly intervals from early April) yielded samples which, when stored in cans or made into jam, proved very unpopular.

In 1960, fruit sprayed up to three times showed no serious taint, except perhaps when made into syrup ; but four, five or six sprays led to higher taint scores and greater (sometimes significant) preferences for control samples over treated ones.

In 1961, however, three 1% sprays applied between 21 March and 2 May did cause taint in canned samples stored for five months.

TABLE I.

TASTING RESULTS ON BLACK CURRANTS SPRAYED WITH LIME SULPHUR.

Treatment	Sample§	Months' storage	Number of triangles: Total	Correct	Wrong	No decision	P_1*	Taint (Average score): Treatment	Control	Correct triangles with control preferred	P_2*
959, 1%, three utomatic sprays	C	6	30	10	18	2	—	0·64	0·23	7	—
	J	6	30	21	5	4	0·1%	1·12	0·31	16	5%
959, 1%, three and sprays	C	6	30	11	12	7	—	0·71	0·10	9	5%
	J	6	32	22	7	3	0·1%	1·09	0·07	17	5%
959, 2%, three and sprays	C	6	32	17	12	3	5%	0·59	0·24	10	—
	J	6	60	10	26	24	—	0·28	0·24	5	—
959, 1%, six prays, ortnightly	C	6	34	23	10	1	0·1%	1·38	0·13	22	0·1%
	S	6	32	10	18	4	—	0·57	0·36	5	—
	J	6	32	23	5	4	0·1%	0·95	0·05	17	5%
960, 1%, ne spray	C	7	24	10	8	6	—	0·11	0·33	1	—
	B	7	28	4	15	9	—	0·41	0·26	1	—
	J	7	28	7	13	8	—	0·55	0·17	5	—
960, 1%, wo sprays	C	7	26	5	8	13	—	0·28	0·23	2	—
	B	7	26	7	5	14	—	0·50	0·54	3	—
	J	7	26	11	8	7	—	0·33	0·36	3	—
960, 1%, hree sprays	C	7	26	13	5	8	—	0·33	0·31	6	—
	B	7	28	12	8	8	—	0·29	0·29	2	—
	J	7	24	9	11	4	—	0·31	0·08	1	—
	S	7	30	19	9	2	0·1%	0·50	0·73	5	—
960, 1%, our sprays	C	7	26	7	13	6	—	0·58	0·38	4	—
	B	7	26	9	2	15	—	0·87	0·51	5	—
	J	7	28	9	12	7	—	0·64	0·14	6	—
	S	7	28	15	9	4	5%	1·00	0·40	11	—
960, 1%, ive sprays	C	7	24	14	7	3	1%	0·75	0·31	9	—
	B	7	28	9	13	6	—	0·55	0·50	5	—
	J	7	28	9	8	11	—	0·43	0·40	3	—
	S	7	30	15	11	4	—	0·78	0·30	8	—
960, 1%, ix sprays	C	7	26	17	7	2	1%	0·97	0·38	12	—
	B	7	26	12	3	11	—	1·42	0·37	10	5%
	J	7	28	18	7	3	1%	0·82	0·29	9	—
	S	7	30	20	9	1	0.1%	0·93	0·44	13	—
961, 1%, hree sprays	C	5	26	14	9	3	5%	0·95	0·26	12	1%

§B = bottled fruit, C = canned fruit, J = jam, S = syrup.
*P_1 = significance level of number of correctly decoded triangles.
P_2 = " " " " " correct triangles with control preferred.

STRAWBERRIES.

The six spray treatments applied at Luddington in 1960 and 1961 were :

Thiram at 10, 20 and 30 days after the opening of blossom ;

Thiram plus dinocap (Karathane) at 10, 20 and 30 days ; also at 20 and 30 days ;

Thiram plus lime sulphur at 10, 20 and 30 days ; also at 20 and 30 days ; also at 30 days.

In 1960, a seventh treatment, thiram plus dinocap at 30 days, was also used. Control samples were scarce in 1960 and not of very good quality ; since no taint could be attributed to dinocap itself in previous trials (1), the control plots in 1961 received dinocap to prevent taints arising from mildew infection. Tasting tests were made on samples of fresh fruit and fruit preserved by canning or deep-freezing. In 1960 there was one pick only, while in 1961 two picks of fruit were available. The results are given in Table II.

In 1960, fresh fruit was not very well liked, as may be seen from the taint scores, but there was no discrimination between control and any treatment. Owing to shortage of control samples, it was possible to examine only four sets

TABLE II.

TASTING RESULTS ON STRAWBERRIES IN 1960 AND 1961.

Treatment	Sample§	Pick	Months' storage	Number of triangles: Total	Correct	Wrong	No decision	P_1*	Taint (Average score): Treatment	Control	Correct triangles with control preferred	P_2*
1960												
Thiram	F	—	—	20	5	11	4	—	0·40	0·60	3	—
at 10, 20, 30 days†	C	—	5	28	15	10	3	5%	0·25	0·79	1	—
Thiram+dinocap	F	—	—	22	8	10	4	—	0·45	0·48	4	—
at 10, 20, 30 days	C	—	5	26	10	14	2	—	0·62	0·27	5	—
Thiram+dinocap	F	—	—	22	8	9	5	—	0·48	0·73	3	—
at 20, 30 days	C	—	5	26	12	13	1	—	0·83	0·38	8	—
	D	—	5	26	3	21	2	—	0·42	0·69	1	—
Thiram+dinocap	F	—	—	16	3	8	5	—	0·58	0·25	0	—
at 30 days	C	—	5	26	12	13	1	—	1·06	0·54	10	5%
	D	—	5	22	7	13	2	—	0·57	0·77	2	—
Thiram+lime sulphur	F	—	—	18	5	9	4	—	0·39	0·56	1	—
at 10, 20, 30 days	C	—	5	28	11	15	2	—	0·48	0·82	3	—
Thiram+lime sulphur	F	—	—	20	6	11	3	—	0·40	0·43	3	—
at 20, 30 days	C	—	5	26	14	12	0	5%	0·87	0·12	11	5%
	D	—	5	26	11	13	2	—	0·77	0·42	7	—
Thiram+lime sulphur	F	—	—	16	9	6	1	—	0·71	0·33	6	—
at 30 days	C	—	5	28	12	12	4	—	0·38	0·96	1**	—
	D	—	5	26	7	16	3	—	0·56	0·62	4	—
1961												
Thiram	F	1	—	26	10	9	7	—	0·51	0·41	6	—
		2	—	26	8	13	5	—	0·56	0·54	4	—
at 10, 20, 30 days	C	1	6	28	24	3	1	0·1%	1·36	0·07	22	0·1%
		2	6	26	14	8	4	5%	0·82	0·13	12	1%
	D	1	6	26	10	14	2	—	0·72	0·49	5	—
		2	6	26	11	14	1	—	0·69	0·58	7	—
Thiram+dinocap	F	1	—	24	9	10	5	—	0·50	0·31	3	—
		2	—	24	7	15	2	—	0·47	0·61	2	—
at 10, 20, 30 days	C	1	6	30	19	7	4	0·1%	0·47	0·53	10	—
		2	6	28	14	11	3	—	0·40	0·62	5	—
	D	1	6	28	13	9	6	—	0·52	0·54	5	—
		2	6	26	11	13	2	—	0·77	0·51	8	—
Thiram+dinocap	F	1	—	24	9	9	6	—	0·31	0·28	3	—
		2	—	26	5	14	7	—	0·49	0·77	0	—
at 20, 30 days	C	1	6	28	9	15	4	—	0·30	0·18	3	—
		2	6	26	11	13	2	—	0·41	0·36	6	—
	D	1	6	26	7	16	3	—	0·56	0·46	4	—
		2	6	22	6	15	1	—	0·61	0·27	4	—
Thiram+lime sulphur	F	1	—	24	8	11	5	—	0·42	0·33	4	—
		2	—	24	8	13	3	—	0·50	0·46	3	—
at 10, 20, 30 days	C	1	6	26	12	12	2	—	0·44	0·36	7	—
		2	6	18	4	13	1	—	0·63	0·44	2	—
	D	1	6	28	12	12	4	—	0·57	0·31	8	—
		2	6	24	13	11	0	5%	0·56	0·53	6	—
Thiram+lime sulphur	F	1	—	26	7	17	2	—	0·54	0·31	4	—
		2	—	26	7	16	3	—	0·72	0·51	4	—
at 20, 30 days	C	1	6	28	12	12	4	—	0·43	0·20	8	—
		2	6	18	3	11	4	—	0·30	0·19	2	—
	D	1	6	28	8	16	4	—	0·64	0·55	6	—
		2	6	22	12	9	1	5%	0·67	0·33	8	—
Thiram+lime sulphur	F	1	—	24	3	18	3	—	0·44	0·36	0	—
		2	—	26	8	15	3	—	0·69	0·56	5	—
at 30 days	C	1	6	30	17	11	2	1%	0·67	0·38	11	—
		2	6	28	12	14	2	—	0·43	0·52	4	—
	D	1	6	28	9	15	4	—	0·64	0·36	8	5%
		2	6	24	7	17	0	—	0·47	0·44	6	—

**10 preferences for treatment (P=5%).
§C=canned fruit ; D=deep-frozen fruit ; F=fresh fruit.
†after opening of blossom.
*P_1=significance level of number of triangles correctly decoded.
P_2= ,, ,, ,, ,, ,, correct triangles with control preferred.

of frozen fruit ; as in the fresh fruit, taint scores were high and discrimination poor. The canned samples were easier to distinguish, and the usual preference for control samples rather than those containing thiram was noted in most cases ; this preference was reversed, however, for three treatments : thiram at 10, 20 and 30 days, thiram plus lime sulphur at 30 days and at 10, 20 and 30 days.

In 1961, there was again no discrimination in fresh fruit with the possible exception that thiram at 10, 20 and 30 days yielded samples which were liked less than the control in the first pick ; no discrimination was shown in the second pick, but there were higher taint scores for most of the treatments and for control. Better discrimination was revealed among the canned samples in 1961 than in 1960, and there was a very clear dislike of fruit sprayed three times with thiram. Thiram plus dinocap at 10, 20 and 30 days, and thiram plus lime sulphur at 30 days, were distinguished from control in both picks, while the remaining treatments were less easily distinguished ; none of the taint scores were as high as those for thiram alone, however. In the frozen fruit, no samples were very popular, and as usual those which contained lime sulphur as well as thiram were most easily distinguished and were liked less than the controls.

Most of these results bear out those obtained in 1959 (1).

Summary.

Black Currants. In tasting trials on black currants sprayed with BHC at concentrations up to 0·014%, no taints were detected on fresh or preserved fruit. BHC at 0·0375% sprayed at advanced grape stage, however, caused definite taint on samples of fruit preserved by canning or deep-freezing.

Malathion at 0·075% left no taint on the fruit.

Lime sulphur at 1%, sprayed three or more times during the season, usually caused marked taint on fruit preserved by any of the normal methods.

Strawberries. Thiram sprayed alone was disliked in samples of fruit canned and stored for five or six months ; indeed all samples containing thiram were suspect when canned. Sometimes taints were also detected in fresh fruit when it had been sprayed three times with thiram. In frozen samples, thiram and lime sulphur together were most easily detected ; frozen strawberries were never very popular under any spray treatment or when unsprayed.

Acknowledgments.

The assistance of Miss M. Leach, the staff of the Domestic Food Preservation section and the members of the tasting panel at Long Ashton is gratefully acknowledged, as is the help of the staff of Luddington Experimental Horticulture Station in supplying strawberries.

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METEOROLOGICAL RECORDS, 1961.

Month	Air Temperature (°F)							Rainfall (″)			Sunshine (hours)		Soil Temperature at 09.00 G.M.T.		
	Means		Means of A & B	Diff. from Normal	Max.	Min.	No. of ground frosts	Total	Per cent of average	Most in a day	Daily mean	Per cent of average	4″	8″	24″
	A Max.	B Min.													
January	45·5	35·4	40·5	+0·1	53	30	21	4·24	126	0·64	1·18	76	38·7	39·6	42·0
February	51·1	41·5	46·3	+5·6	59	53	6	2·59	102	0·46	2·16	89	44·2	44·2	45·1
March	54·4	38·0	46·2	+3·2	68	27	19	0·16	7	0·10	4·65	119	44·7	44·9	46·5
April	57·0	45·0	51·0	+3·4	64	39	9	3·85	176	0·60	2·83	52	51·4	50·6	50·8
May	60·7	44·0	52·5	—0·6	67	33	10	1·25	48	0·30	6·87	110	56·0	55·1	55·6
June	67·3	49·0	58·2	—0·3	83	43	1	1·29	58	0·85	8·74	124	62·9	60·0	60·1
July	68·3	53·0	60·6	—0·9	81	44	0	2·81	90	0·70	6·20	95	63·7	63·0	63·2
August	68·2	53·3	60·7	—0·6	85	44	0	3·00	82	0·69	5·61	95	61·7	61·5	63·0
September	67·9	52·9	60·4	+3·3	83	42	0	2·49	77	0·36	4·21	90	60·2	60·7	62·2
October	56·9	46·0	52·4	+1·3	67	32	2	3·38	87	0·63	3·54	108	51·8	52·9	57·0
November	49·1	38·3	43·7	—1·1	59	27	14	1·61	44	0·48	1·92	102	43·9	45·5	49·7
December	42·6	32·6	37·5	—3·9	59	19	24	4·29	117	1·17	1·88	127	38·4	39·8	44·5
Totals or Means ..	57·4	44·1	50·8	+0·7			106	30·96	86		4·15	100	51·5	51·5	53·3

G. E. Clothier

THE JOURNAL OF HORTICULTURAL SCIENCE.

The Journal of Horticultural Science exists to publish results of research on fruit and other perennial crops, vegetables and flowers. The Publication Committee welcomes papers from both temperate and tropical countries describing original investigations of interest to those engaged in scientific research and the practice of horticulture. Papers for publication and all communications should be sent to the Editors, East Malling Research Station, Maidstone, Kent.

Papers in the current Volume 37 (1962) come from the Research Stations at Long Ashton and East Malling, the Glasshouse Crops Research Institute, the National Vegetable Research Station, the Bee Research Department at Rothamsted, Reading University and Wye College, the N.A.A.S., and from California, New South Wales and New Zealand. A diverse selection of horticultural crops is covered; e.g. apples, pears, plums and black currants; vines; spring cabbage and peas; tulips and carnations.

Several papers report nutritional studies, including effects on crop and leaf nutrient status of young dessert apples; the manuring of vegetables and flowers. Other subjects discussed are the effect of winter temperature on flowering, frost damage, the causes and control of variability, pollination, storage, propagation, viruses (including evidence that bitter pit in apples is not due to a virus), the inheritance of woolly aphid resistance, codlin moth, and silver leaf in plums.

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